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MASSAGE: ITS MODE OF APPLICATION AND EFFECTS.

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"MASSAGE," from the Greek *masso* (I knead or handle), is a term now generally accepted to signify a group of procedures which are usually done with the hands, such as friction, kneading, manipulating, rolling, and percussing of the external tissues of the body, either with some curative, palliative, or hygienic object in view. Its application should in many instances be combined with passive, resistive, or assistive movements, and these are often spoken of as the so-called Swedish movement-cure. There is, however, an increasing tendency on the part of scientific men to have the word "massage" embrace all these varied forms of manual therapeutics, for the reason that the word "cure," attached to any form of treatment whatsoever, can not always be applicable, inasmuch as there are many maladies that preclude the possibility of recovery and yet admit of amelioration. Hence the word "cure" may lead people to expect too much; and, on the other hand, the use of the word "rubbing" in place of "massage" tends to undervalue the application and benefit of the latter, for it is but natural to suppose that all kinds of rubbing are alike, differing only in the amount of force used.

According to the requirements of individual cases, massage may be of primary importance or of secondary importance, of no use at all, or even injurious. Concerning the extent of its usefulness, it may with safety be said that, at tolerably definite stages in one or more classes of affections in every special and general department of medicine, evidence can be found that it has proved either directly or indirectly beneficial, or led to recovery, sometimes when other means had been but slowly operative, or apparently had failed altogether.

In view of these facts, it need hardly be said that those who would properly understand and apply massage should be familiar with its past and present literature; they should also be familiar not only with the natural history of the maladies in which massage may be applied when left to themselves, but also with the course of these affections when treated in the usual approved methods, so that improvements or relapses may be referred to their proper causes. Moreover, they should know something about the methods of others who have any claim to respectability in their manner of applying massage, so as to compare them with their own. And yet all these qualifications may fail if the operator has not in addition abundance of time, patience, strength, and skill, acquired by long and intelligent experience. Measured by these requirements, I fear that good *masseurs* (manipulators) are scarce. Dr. E. C. Seguin, in the "Archives of Medicine" for April, 1881, says, that even in New York there are few manipulators who can be trusted to do massage well. Massage may be studied as a science, but it has, like everything else in medicine and surgery, to be practiced as an art. Those who have a natural tact, talent, and liking for massage, united with soft, elastic, and strong hands, and physical endurance to use them, may be as useful artists in this department of the healing art as in others. It has been well said that those who do massage should be tender and gentle, yet strong and enduring. These are qualities that are rarely found combined in manipulators. It is a very common mistake to suppose that those who are of a remarkably healthy, ruddy appearance, plethoric and fat, are the best fitted to do massage. Such people require a great deal of exercise in the open air for the proper oxygenation of their blood, and confining, in-door work, like massage, they soon find to be tedious and irksome. Besides, the stooping attitude and varying positions so often necessary while doing this sort of work soon put them out of breath; and thus, while suffering from their ignorance and awkwardness, they fancy they are imparting "magnetism" to their patients at their own expense. Better that the manipulators should be rather thin, though if of too spare a habit their hands will not be sufficiently strong and muscular and their tissues generally will lack that firmness necessary for prolonged endurance.

One of the best German medical reviews, "Schmidt's Jahrbücher," in an extensive report on massage, thus indicates the esteem in which this treatment is held by many eminent physicians and surgeons of Europe: "It is but recently that massage has gained an extensive scientific consideration, since it has passed out of the hands of rough and ignorant empirics into those of educated physicians; and upon the results of recent scientific investigations it has been cultivated into an improved therapeutical system, and has won for itself in its entirety the merit of having become a special branch of the art of medicine." Professor Billroth, one of the most eminent surgeons of

Germany, in a lecture on this subject published in the "Wiener med. Wochen.," No. 45, 1875, says: "I can only agree with my colleagues, Langenbeck and Esmarch, that massage in suitable cases deserves more attention than has fallen to its lot in the course of the past ten years in Germany. . . . As practice in the manipulations, time, perseverance, and personal interest in the matter are necessary, and these one can not bestow who interests himself much in medicine and surgery, I have turned over to my old experienced surgical assistant suitable cases for massage, and he has already obtained a series of results both favorable and surprising, and far exceeding my expectations of this method of treatment." Previous to the past fifteen years the French physicians took more interest in massage than any others, but of late they have almost entirely laid it aside. With their waning interest the Scandinavians and Germans have taken up the subject with renewed zeal, and from time to time furnish instructive accounts of their experiments, successes, and failures.

How is massage regarded, and what is its condition, in the United States? Except among very few—epicures in this matter, if one may so speak—there is as yet but little evidence of a desire to place massage, and those who do it, on their merits alone, irrespective of the policy of employing persons who are only rubbing-machines, or of tolerating obnoxious individuals so long as the poor patients' minds are satisfied. This is too often the case, and then massage is said to have failed and valuable time is lost, when, if it had been properly applied, it might have been successful; or, on the other hand, perhaps it should have been omitted and other remedies employed. The writer of this, in a recent paper on the "History of Massage," has said: "In almost every city of the United States, and indeed of the whole civilized world, there may be found individuals claiming mysterious and magical powers of curing disease, setting bones, and relieving pain by the immediate application of their hands. Some of these boldly assert that their art is a gift from Heaven, due to some unknown power which they call magnetism, while others designate it by some peculiar word ending with *pathy* or *cure*, and it is astonishing how much credit they get for their supposed genius by many of the most learned people." Let a fisherman forsake his boat, or a blacksmith his anvil, or a carpenter his bench, or a shoe-maker his shop, and proclaim that he has made the wonderful discovery that he is full of magnetism and can cure all diseases, and, be he ever so ignorant and uncouth, he is likely to have, in a remarkably short space of time, a large *clientèle* of educated gentlemen and refined ladies. It is not meant to imply that the previous occupation of such people is at all to their discredit, but, were they capable of giving a rational explanation of their doings, the halo of mystery would be removed from around them, and their prestige and patronage would suffer a sudden decline.

In Boston and Philadelphia, and perhaps in other cities as well,

efforts have been made by physicians, who are thoroughly familiar with massage, to instruct intelligent nurses and others how to apply it, and at the training-schools for nurses the pupils receive some general instruction in the matter. In this way something has been accomplished to bring massage within the rules and regulations of common sense and rational therapeutics. But still there is great room for improvement even in this direction, for it is but too often the case that after one or two persons are specially trained to do massage they are requested to give instruction to some of the pupils at the schools for nurses, and to others, a few of whom, after having received some general desultory lessons, are in turn delegated or relegated to teach others, and so on, until, by the time massage reaches the needy patients, there is often little left of it but the name. Hence it is not to be wondered at that many a shrewd, superannuated auntie, and others who are out of a job, having learned the meaning of the word massage, immediately have it printed on their cards, and keep on with their "rubbin'" just as they always have done.

The vaguest generalities exist as to the manner of doing massage, even among the best authors on the subject, and, after having studied and tried the methods of all, the writer proposes to briefly formulate, as much as space will permit of, what he has found to be of value, without having adopted the methods of any in particular. By so doing it is hoped that some will be able to judge whether those employed to do massage know anything about it or not, or whether it would not be as well to employ one of their own domestics for ordinary rubbing, the advantages of which are not to be despised. At any rate, from the description which follows, I trust that not a few intelligent friends of chronic invalids, who are beyond the reach of the professional manipulator, will be enabled to apply massage so as to afford even greater relief and comfort than can be gained from many of those whom the ignorance of the community on this subject alone tolerates as experts.

The multiform subdivisions under which the various procedures of massage have been described can all be grouped under four different heads, viz., friction, percussion, pressure, and movement. Malaxation, manipulation, deep-rubbing, kneading, or massage, properly so called, is to be considered as a combination of the last two. Each and all of these may be gentle, moderate, or vigorous, according to the requirements of the case and the physical qualities of the operators. Some general remarks here will save repetition: 1. All of the single or combined procedures should be begun moderately, gradually increased in force and frequency to their fullest extent desirable, and should end gradually as begun. 2. The greatest extent of surface of the fingers and hands of the operator consistent with ease and efficacy of movement should be adapted to the surface worked upon, in order that no time be lost by working with the ends of the fingers or one

portion of the hands when all the rest might be occupied. 3. The patient should be placed in as easy and comfortable a position as possible, in a well-ventilated room at a temperature of about 70° Fahr. 4. What constitutes the dose of massage is to be determined by the force and frequency of the manipulations and the length of time during which they are employed. A good manipulator will do more in fifteen minutes than a poor one will in an hour, just as an old machanic working deliberately will accomplish more than an inexperienced one working furiously. Friction has been described as rectilinear, vertical, transverse or horizontal, and circular. It has been stated, and very properly, that rectilinear friction should always be used in an upward direction, from the extremities to the trunk, so as to favor and not retard the venous and lymphatic currents. But a slight deviation from this method I have found to be more advantageous, for though in almost every case the upward strokes of the friction should be the stronger, yet the returning or downward movement may with benefit lightly graze the surface, imparting a soothing influence, without being so vigorous as to retard the circulation, and thus a saving of time and effort will be gained. The manner in which a carpenter uses his plane represents this forward-and-return movement very well. Transverse friction, or friction at right angles to the long axis of a limb, is a very ungraceful and awkward procedure. It has been introduced on theoretical considerations alone, and may with safety be laid aside, for the method already spoken of, together with circular friction, will do all and a great deal more than rubbing crosswise on a limb can do. A convenient extent of territory, to begin with, is from the ends of the fingers to the wrist, each stroke being of this length, the returning stroke being light, without raising the hand. The rapidity of these double strokes may be from one hundred to one hundred and fifty a minute. The whole palmar surface of the fingers should be employed, and in such a manner that they will fit into the depressions formed by the approximation of the phalanges and metacarpal bones. The heel of the hand should be used for especially vigorous friction of the palm, as well as for the sole of the foot. From the wrist to the elbow, and from the elbow to the shoulder, are separately convenient extents of surface, and here not only straight-line friction, extending from one joint to the other, may be used, but also circular friction. The form of the latter which I have found most serviceable is in that of an oval, both hands moving at the same time, the one ascending as the other descends, at the rate of one hundred and twenty-five to two hundred and fifty each a minute, or two hundred and fifty to five hundred with both hands, each stroke reaching from joint to joint, the upward stroke being carefully kept within the limits of chafing the skin. These observations apply to the lower limbs also, but, as they are larger than the arms, the posterior and lateral aspects, from ankle to knee, will be a convenient

territory, while the anterior and lateral aspects will be another for thorough and efficacious friction. The same systematic division of surface may be made above the knees as below, the number of strokes below will vary from one hundred to one hundred and sixty with each hand; above, from seventy-five to one hundred each. From the base of the skull to the spine of the scapula forms another region naturally well bounded for downward and outward semicircular friction, and from the spine of the scapula to the base of the sacrum and crest of the ilium forms another surface over which one hand can sweep, while the other works toward it from the insertion to the origin of the glutei, at an average rate of sixty or seventy-five a minute with each hand for a person of medium size. It will be observed that on the back and thighs the strokes are not so rapid as on the other parts mentioned, for the reason that the skin is here thicker and coarser, in consequence of which the hand can not glide so easily, and the larger muscles beneath can well bear stronger pressure; besides, the strokes are somewhat longer, all of which require an increased expenditure of time. The chest should be done from the insertion to the origin of the pectoral muscles, and the abdomen from the right iliac fossa in the direction of the ascending, transverse and descending colon. But here friction is seldom necessary, for the procedure about to be considered accomplishes all that friction can do, and a great deal more in this region. The force used in doing friction is often much greater than is necessary, for it is only intended to act upon the skin, and there are better ways of acting upon the tissues beneath it. If redness and irritation be looked upon as a measure of the beneficial effects of friction upon the skin, then a coarse towel, a hair mitten, or a brush would answer for this purpose a great deal better than the hand alone.

The most important, agreeable, and efficacious procedure of massage has been variously designated as manipulation, kneading, deep-rubbing, or massage properly so called, in contradistinction to the more superficial method spoken of above. This is done by adapting as much as possible of the fingers and hands to the parts to be thus treated, and, without allowing them to slip on the skin, the tissues beneath are kneaded, rolled, and manipulated in a circulatory manner, proceeding from the insertion toward the origin of the muscles, from the extremities to the trunk, in the direction of the returning blood and lymphatic currents. For this purpose the same divisions of surface as for friction will be found most convenient. Beginning then with the fingers from the roots of the nails, the thumb of the manipulator will be placed on one of the fingers of the patient, and parallel to the latter, while on the opposite side the index-finger will be placed at right angles to this, and between the two the finger of the patient will be compressed and malaxated, in a rotary manner, at the rate of seventy-five to one hundred and fifty per minute. The dorsal and palmar surfaces will of course receive special attention, while the

lateral aspects will come in for a secondary share. If the manipulator be sufficiently expert he can work with both hands on this small surface with the same rapidity as with one. Each finger and thumb will be taken in turn, and the manipulations extended over the metacarpal and carpal bones as far as the wrist-joint, and finally the palm of the hand by stretching the tissues vigorously away from the median line. Each part included in a single grasp may receive three or four manipulations before proceeding onward to the adjacent region. The advance upon this should be such as to allow the finger and thumb to overlap one half of what has just been worked upon. Advance and review should thus be systematically carried on, and this is of general application to all the other tissues that can be *masséed*. The force used here and elsewhere must be carefully graduated so as to allow the patient's tissues to glide freely upon each other; for, if too great, the movement will be frustrated by the compression and perhaps bruising of the tissues; if too light, the operator's fingers will slip; and, if gliding with strong compression be used, the skin will be chafed. To avoid this last objection various greasy substances have been employed, so that ignorant would-be masseurs may rub without injuring the skin. When the skin is cold and dry, and the tissues in general are insufficiently nourished, as well as in certain fevers and other morbid conditions, there can be no doubt of the value of inunction; but no special skill is required in order to do this, and there is no need of calling it massage unless it be to please the fancy of the patient.

The feet may be dealt with in the same manner as the hands, using the ends of the fingers to work longitudinally between the metatarsal as well as between the metacarpal bones. Upon the arms and legs, and indeed upon all the rest of the body, both hands can be used to better advantage than where the surfaces are small. Each group of muscles should be systematically worked upon, and for this purpose one hand can usually be placed opposite to the other and in advance of it, so that two groups of muscles may be manipulated at the same time. When the circumference of the limb is not great, the fingers of one hand will partly reach on to the territory of the other, while grasping, circulatory, spiral manipulations are made, one hand contracting as the other relaxes, the greatest extension of the tissues being upward and laterally, and on the fore-arms and legs away from the median line. Subcutaneous bony surfaces, as those of the tibia and ulna, incidentally get sufficient attention while manipulating their adjacent muscles, for, if both be included in a vigorous grasp, unnecessary discomfort results. Care should be taken not to place the fingers and thumb of one hand too near those of the other, for by so doing their movements would be cramped. The elasticity, or want of it, in the patient's tissues, should be the guide, the object being to obtain their normal stretch, and in this every person is a law to himself, the character of their tissues varying with the amount and quality of

adipose, modes of life, exercise, etc. A frequent error on the part of manipulators is in attempting to stretch the tissues in opposite directions at the same time, especially at the flexures of the joints, where the skin is delicate and sensitive, and where the temptation to such procedures is greatest because easiest, the effect being a sensation of tearing of the skin. The rate of these manœuvres varies from seventy-five to one hundred and fifty with each hand per minute on the arms, from sixty to ninety on the legs, and from forty to eighty on the thighs, where more force is required on account of the larger size and density of the muscles, and the need of using sufficient force to extend beneath the strong, tense fascia lata.

On the back the direction of these efforts will be from the base of the skull downward, stretching the tissues away from the spinal column while manipulating in graceful curves at an average rate of sixty per minute with each hand. And here one hand can often be re-enforced by placing the other upon it, and thus massage may be done with all the strength the manipulator can put forth. With the ends of the fingers the muscles on each side of the spinal column can be rolled, and the supra-spinous ligament can be effectually *massèed* by transverse to-and-fro movements. The ends of the fingers and part of their palmar surface should also be placed on each side of the spinous processes, and the tissues situated between these and the transverse processes worked upon by up-and-down motions parallel to the spine, taking care to avoid the too frequent error of making pushing, jerky movements in place of smooth, uniform motions in each direction.

On the chest and abdomen the same general direction will be observed as in using friction, but the manipulation will be more gentle than on the back and limbs, for the tissues will not tolerate being so vigorously squeezed and pinched. Here the massage will consist of moderate pressure and movement with the palms of the hands, and rolling and grasping the skin and superficial fascia; and, after this, on the abdomen, steady, firm, deep kneading in the direction of the ascending, transverse, and descending colon, using for this purpose the greatest force with the heel of the hand on the side of the abdomen next the operator, and on the other side the strongest manipulations with the fingers, avoiding the frequent and disagreeable mistake of pressing at the same time on the anterior portions of the pelvis.

Before leaving this part of the subject, the writer begs leave to say something more about the common errors into which manipulators fall, even some of those who pass for being skillful. Many do not know how to do the kneading or malaxation with ease and comfort to themselves and to their patients, for, in place of working from their wrists and concentrating their energy in the muscles of their hands and fore-arms, they vigorously fix the muscles of their upper arms and shoulders, thus not only moving their own frame with every

manipulation, but also that of their patients, giving to the latter a motion and sensation as if they were at sea in stormy weather. By this display of awkward and unnecessary energy, not only do they soon tire themselves, and say that they have lost magnetism by imparting it to their patients, but by the too firm compression of the patient's tissues they are not allowed to glide over each other; and hence such a way of proceeding entirely fails of the object for which it is intended. Surely, cultivation is the economy of effort.

Friction and manipulation can be used alternately, varied with rapid pinching of the skin and deeper grasping of the subcutaneous cellular tissue and muscular masses, and, when necessary, with percussion, passive, assistive, and resistive movements, finishing one convenient surface or limb before passing to another, and occupying from half an hour to an hour with all or part of these procedures. Pinching is used mainly to excite the circulation and innervation of the skin, and for this purpose it is best done rapidly at the rate of one hundred to one hundred and twenty-five per minute with each hand. To act on the subcutaneous cellular tissue, a handful of skin is grasped and rolled and stretched more slowly than by the preceding method. A deeper, momentary grasping of the muscles is often advantageous, and may be called a *mobile intermittent compression*, and this, indeed, is what the whole of massage, strictly speaking, consists of. Percussion, applicable only over muscular masses, may be done in various ways. In the relative order of their importance they are as follows: 1. With the ulnar borders of the hands and fingers. 2. The same as the first, with the fingers separated. 3. With the ends of the fingers, the tips being united on the same plane. 4. With the dorsum of the upper halves of the fingers loosely flexed. 5. With the palms of the hands. 6. With the ulnar borders of the hands tightly shut. 7. With the palms of the hands held in a concave manner, so as to compress the air while percussing. More gentle or vigorous and rapid percussion than any of these methods afford can be done by securing India-rubber air-balls on whale-bone or steel handles. With these one gets the spring of the handles together with the rebound of the balls, and thus rapidity of motion with easily varying intensity is gained, the number of blows varying from two hundred and fifty to six hundred a minute with both.

Remedial movements have been so well described in books on the so-called "movement-cure" that little need be said of them here. It is well for those who use them to know the anatomy and physiology of the joints and their natural limits of motion. Except in the case of relaxed joints, passive motion should be pushed until there is a feeling of slight resistance to both patient and manipulator; for by this will be known that in healthy joints the ligaments, capsules, and attachments of the muscles are being acted upon. Resistive movements are such as the patient can make while the operator resists. The opposing

force should be carefully and instinctively kept within the limits of the patient's strength, and this, with all these other manœuvres, should stop short of fatigue. To alternately resist flexion and extension is the *pons asinorum* of manipulators, and, in a considerable experience of teaching massage, I have found but few who could learn to do it at all. Its importance can not be overestimated as a means of cultivating the strength of weakened muscles, while, at the same time, finding out how much they can be used. Many a patient who has recovered from an old injury is still as much incapacitated as ever, from the fact that his latent energies can only be discovered and made available in this manner. Midway between passive and resistive movements, in the course of certain recoveries, stand assistive movements. They are but little understood and seldom used. They may be illustrated as follows: Let it be supposed that, in the absence of adhesions and irreparable injury of the nerve-centers, the deltoid has but half the strength requisite to elevate the arm. So far as any use is concerned this is the same as if there were no power of contraction left in the muscle. But, if only the other half of the impaired vigor be supplemented by the carefully graduated assistance of the operator, the required movement will take place; and, in some cases, if this be regularly persisted in, together with manipulation and percussion, more vigorous contraction will be gained, and, by-and-by, the patient will exert three fourths of the necessary strength, and later the whole movement will be done without aid; and, as strength increases, resistance can be opposed to the movement. Partial loss of motion can often be accurately estimated by holding the limb suspended in a cloth attached to a spring-balance. When the patient makes effort the limb weighs less. By means of a spring-balance resistive motion can also be estimated. Still another kind of movement may be spoken of—namely, vigorous passive motion—with a view to breaking up adhesions in and about joints, a description of which does not come within the scope of this paper. It is the secret of success and of failure of the people who call themselves "bone-setters," the methods of whom have been well studied and explained by Dr. Wharton P. Hood, of London, in his very interesting book "On Bone-Setting, so called."

A description of massage of the head and the benefits that arise from it must be left to another time.

The relative importance of the foregoing procedures has been partly indicated while describing them. According to the needs of individual cases, one or more of these will predominate or be omitted, and it is well that the advice of a physician be sought on this subject, for there would be no use in giving a patient friction the capillary circulation of whose skin was already sufficiently good; and it would be a waste of time and strength to administer passive and resistive movements to patients who were already fatigued from overwork. To rouse the dormant action of cold skin and flabby muscle, percussion will be

of the first importance, and will alternate with friction and manipulation. Percussion is in massage what faradization is in electricity, and will often answer the same purpose; manipulation, or deep-kneading, is to massage what the constant current is to electricity, and the ultimate effects of each are very much alike. In "Schmidt's Jahrbücher" and elsewhere numerous instances are given in which massage has succeeded, after electricity and other means had failed. The reverse of this may be true, but as yet I have not seen any proof of it. Let us now speak of the general effects of massage, and, further on, its influence more in detail. And, first, it may be well to premise that it requires, on the part of the patient a certain amount of latent energy, if one may so call it, in order to undergo even a minimum *séance* of massage; for a patient may be so weak as to preclude the possibility of its being applied without harm resulting. In properly selected cases, instances of which are frequently seen in individuals suffering from overwork, or want of work, worry, depression of spirits, and loss of sleep, together with feeble and tardy digestion—those who can not get or take rest, no matter how favorable the opportunity—the effects of massage are generally as follows: While it is being done, and often for several hours afterward, the patients are in a blissful state of repose; they feel as if they were enjoying a long rest, or had just returned from a refreshing vacation, and not a few say that it makes optimists of them for the time being. It produces warmth, comfort, and sleep; relieves or cures constipation, muscular pains, and stiffness. At the same time it exerts a peculiarly delightful and profound effect upon the nervous system, its influence being tonic, sedative, and physiologically counter-irritant, making more blood flow through the skin and muscles, and consequently less to the brain, spinal cord, and internal organs. To those to whom exercise would be injurious, massage affords the advantages of exercise without exertion while the subjects of it are resting, their over-taxed will and used-up nervous energy not being required to express themselves in voluntary motion. For reasons such as these, we find no less an authority than the British "Journal of Mental Sciences" (for April, 1878) recommending "massage for certain melancholics, with trophic and vaso-motor affections, and also where dementia is threatened after an attack of excitement. Under this treatment mental comfort and a sense of well-being take the place of apathy and lassitude."

Lord Bacon has quaintly remarked that "repair is procured by nourishment, and nourishment is promoted by forwarding internal *concoction*, which drives forth the nourishment, as by medicines that invigorate the principal viscera; and, secondly, by exciting the external parts to attract the nourishment, as by exercise, proper frictions, etc." Massage excites the external parts to attract and assimilate the nourishment, brought thither by an increased volume of blood, and this, at the same time, favors absorption of the natural worn-out

débris. The different ranks of the Sandwich-Islanders are of different stature; and we are told that the chiefs, though sunk in sloth and immorality, are not diminutive and decrepit, like many of their countrymen, for the reason that they fare sumptuously, take little or no exercise, and are *lomi-lomied* after every meal, in order to aid their digestion and promote their circulation without inducing fatigue or exhaustion. *Lomi-lomi* is thus interestingly described by Nordhoff, in his book on "Northern California, Oregon, and the Sandwich Islands": "Wherever you stop, for lunch or for the night, if there are native people near, you will be greatly refreshed by the application of *lomi-lomi.* Almost everywhere you will find some one skilled in this peculiar, and, to tired muscles, delightful and refreshing treatment. To be *lomi-lomied,* you lie down upon a mat, or undress for the night, if you prefer. The less clothing you have on the more perfectly the operation can be performed. To you, thereupon, comes a stout native, with soft, fleshy hands, but a strong grip, and beginning with your head, and working down slowly over the whole body, seizes and squeezes with a quite peculiar art every tired muscle, working and kneading with indefatigable patience, until, in half an hour, whereas you were weary and worn out, you find yourself fresh, all soreness and weariness absolutely and entirely gone, and mind and body soothed to a healthful and refreshing sleep. The *lomi-lomi* is used not only by the natives, but among almost all the foreign residents; and not merely to procure relief from weariness, consequent upon over-exertion, but to cure headaches, to relieve the aching of neuralgic or rheumatic pains, and, by the luxurious, as one of the pleasures of life. I have known it to relieve violent headache in a very short time. The chiefs used to keep skillful *lomi-lomi* men in their retinues; and the late king, who was for some years too stout to take exercise, and was yet a gross feeder, had himself *lomi-lomied* after every meal, as a means of aiding his digestion. It is a device for relieving pain and weariness which seems to have no injurious reaction, and no drawback but one—it is said to fatten the subjects of it."

Dr. Weir Mitchell has successfully proved that many chronic invalids can be cured by rest and excessive feeding, made possible by means of massage and electricity. Under this combination of treatment, skillfully carried out, many become fat, strong, and well, thus illustrating the truth of Lord Bacon's remark, and the beneficial effects of the not very scientific massage of the Sandwich-Islanders. The *lomi-lomi* of the Sandwich-Islanders is only a series of intermittent squeezes proceeding toward the extremities, thus hindering the returning circulation; and this illustrates another fact—that many who have had but one kind of pinching and squeezing think it is "excellent" until they try some one who understands and can do it better; moreover, it shows that any sort of stirring up of the tissues is often better than none. In using massage, as much depends on the qualities and

qualifications of the person who does it as in any other occupation. It would be wrong to leave the impression that massage is always agreeable from the first. In proportion as the muscles, superficial fascia, and skin are unnaturally tough, tense, *matted* and *hide-bound*, will the massage be disagreeable until they become soft, supple, and elastic. An appreciation of the proper consistence of the tissues and their anatomical structure is of the utmost importance for the success of this treatment.

But we must hasten to consider how massage acts locally. By upward and oval friction, with deep manipulation, the veins and lymphatics are mechanically emptied—the blood and lymph are pushed along more quickly by the additional *vis a tergo* of the massage, and these fluids can not return by reason of the valvular folds on the internal coats of their vessels. Thus, not only is more space created for the returning currents arising from beyond the region *masséed*, but, at the same time, a vacuum is formed, which is visible in the superficial veins of persons who are not too fat; and this is thought by some to add a new force to the more distal circulation. In this way the collateral circulation in the deeper vessels is aided and relieved, as well as the more distal stream in the capillaries and arterioles. One would naturally suppose that the circulation in the larger arteries would, in this manner, be interrupted, and such is the case. But, herein comes an additional advantage to aid the circulation, for the temporary and momentary intermittent compression causes a dilatation of the artery from an increased volume of blood above the part pressed upon, and this accumulation rushes onward with greater rapidity as soon as the pressure is removed, in consequence of the force of the heart's action and the resiliency of the arteries acting upon the accumulated volume of blood.

But the same pressure also acts upon the tissues external to the vessels, causing a more rapid resorption of natural or pathological products through the walls of the venous capillaries and lymphatics. When muscular nerves are stimulated, the vaso-dilators are influenced, and this takes place by massage, whence follows enlargement of the lumen of the vessels, so that an increased flow passes through them with greater ease and diminished pressure. When stimuli are applied to the skin, reflex vaso-motor action shows that the vaso-dilators are acted upon, hence the redness and congestion of the skin when massage is specially directed to it. It can be readily seen now that massage rouses dormant capillaries, increases the area and speed of the circulation, furthers absorption and stimulates the vaso-motor nerves, all of which are aids and not hindrances to the heart's action, as well as to nutrition in general. Seeing that more blood passes in a given time, there will be an increase in the total interchange between the blood and the tissues, and thus the total amount of work done by the circulation will be greater and the share borne by each quantity of

blood less. It will not be surprising, then, to learn that in practice massage sometimes proves a valuable ally in the treatment of functional and organic diseases of the heart, for "the peripheral friction of the blood against the walls of the capillaries and small arteries not only opposes the flow of blood through them, but, working backward along the whole arterial system, has to be overcome by the heart at each systole of the left ventricle." This obstacle is in great part lessened by massage. In exercise there is alternate contraction and relaxation of voluntary muscles, and this is a powerful aid to the circulation in general; for at each contraction the vessels are emptied by compression, and the alternating relaxation allows them to fill up again. Thus each muscle or group of muscles in activity has been appropriately likened to a beating heart. In this respect the intermittent pressure of massage aids and imitates the alternate contraction and relaxation of muscles very accurately, and no better praise could be bestowed upon any therapeutical agent than the old-fashioned, haughty, supercilious way of dismissing the subject of massage as unworthy of notice by saying that it was merely a substitute for exercise. Exercise favors all the functions, and people who can exercise freely without fatigue, and who can eat and sleep well, seldom need massage. I am aware that this statement includes many neurasthenics, especially those who suffer from want of occupation.

While undergoing massage it is well for the patient to take frequent and deep inspirations, in order to favor the flow of the venous and lymphatic currents to the thorax. This, however, is often instinctively done, and with such ease that the patient feels as if freed from an immense load. From a paper by Professor H. P. Bowditch, in the "Proceedings of the American Academy of Arts and Sciences," for 1873, "On the Lymph-Spaces in Fasciæ," we learn the following valuable and interesting facts: "In experiments on animals where the flow of lymph through the thoracic duct was measured, passive movements of the limbs increased this flow in a remarkable manner. Galvanization of the muscles had a similar but less powerful effect. The lymph-spaces existing between the tendinous fibers of fasciæ and the connection of these spaces with lymphatic vessels have been described by Ludwig and others. By virtue of this structure the fasciæ play an important part in keeping up the flow of lymph through the lymphatic vessels. A piece of fascia was removed from the leg of a dog and tied over the mouth of a glass funnel, with the side next the muscles uppermost. A few drops of a colored turpentine solution were then placed upon this surface, and the fascia alternately stretched and relaxed by partially exhausting the air from the funnel and allowing it to return again. In this way the coloring matter was made to penetrate into the spaces between the fibers of the fascia and to enter the lymph-spaces on the opposite side. The same result was obtained when the coloring matter was injected between the muscles and the

fascia, and the latter stretched and relaxed by passive movements of the limb. The alternate widening and narrowing of the lymph-spaces between the tendinous fibers seems, therefore, to cause absorption of the lymph from the neighboring parts as well as its onward flow into the lymphatic vessels." This function of the fascia certainly affords a partial, important, and, so far as it goes, very satisfactory explanation of the success of methods of treatment which involve passive motion, for the removal of effete matters from the tissues is favored by an increased flow of lymph.

But Nature, as one of her regular functions, is continually performing this experiment in the voluntary and involuntary movements of the muscles. The large serous cavities, such as those of the pleura and peritonæum, are now regarded as extensive lacunæ in the course of the lymphatic vessels; lymph-spaces and lymphatic vessels, communicating with each other by means of small openings or stomata, have been demonstrated in these membranes, and also the communication of the lymph-spaces with the pleural and peritoneal cavities by means of intercellular openings. This has been shown by injecting either of these cavities with colored fluid, and, after killing the animal, examining the course of absorption of the fluid under the microscope. In the movements of respiration, alternate expansion and contraction of the chest-walls, with descent and ascent of the diaphragm, we have a continual pump-like action of absorption and onward expulsion in the lymph-spaces and lymphatic vessels of the pleura and peritonæum. But we must not forget that the capillary blood-vessels are similarly influenced, nor should we fail to remember that osmosis may also play a very important part, and that this, too, can be increased by artificial pressure. We can now understand why the kings of the Sandwich Islands should be *lomi-lomied* after every meal in order to aid their digestion, for the externally applied pressure over the abdomen would force the contents of the lacteals, or lymphatics of the small intestine, onward, at the same time aiding them in their absorption of digestive products.

Professor von Mosengeil, of Bonn, has made some interesting and useful experiments by injecting the cavities of corresponding joints of rabbits with Indian ink, and in this way proving that resorption takes place from these cavities by means of lymph-spaces and stomata, communicating with lymphatic vessels, and through these with lymphatic glands. With each rabbit he *masséed* one of the joints and left the corresponding joint untouched. The swelling that arose from the injection always disappeared rapidly under massage, and, upon examination of the *masséed* joint, it was found emptied for the most part of its colored contents. Even when the examination was made shortly after the injection and the use of massage, there was proportionately little ink found in the joint, part of it was found upon the synovial membrane; and upon microscopic examination it was seen that the

greatest part had been forced into, and had penetrated through, the synovial membrane, and the darkened lymphatics could be seen with the unaided eye from the injected joint to the lymphatic glands, and these latter were black from the absorption of the ink. Upon examination of the injected joint-cavities that had not been *masséed*, the ink was still found in the joint mixed with the synovia in a smeary mass, and it had not even penetrated into the tissue of the synovial membrane. With the removal of the effusion by the use of massage, Von Mosengeil always succeeded in improving the stiffness, and in obtaining the same appearances in the lymphatics.

From clinical experience in the use of massage in joint affections, such results as those obtained by Von Mosengeil might have been with safety predicted. A consideration of the mode of application of massage in joint injuries and affections, and its relations to mechanical support, rest, and exercise, would far exceed the limits of this paper. Scandinavian, German, and French army-surgeons, who with their own hands have used massage the most in joint maladies, have accumulated respectable and trustworthy statistics showing its great value in such cases. At the same time they have not forgotten to tabulate their failures. The result of their experience in recent joint injuries admitting of the application of massage is thus formulated: "*It will simultaneously further and increase resorption, accelerate the circulation, relieve pain, and reduce elevated temperature.*" I have illustrated this by a report of over three hundred cases, the details of which may be found in the "New York Medical Record," No. 353. The "Nouveau Dictionnaire de Médecine" clearly expresses the action of massage in the following words: "Massage augments interstitial absorption not only by the *sur-activité* impressed upon the returning circulation, but also by dividing to infinity pathological and normal products accumulated in the muscular interstices and meshes of the cellular tissue. The dissemination of these products multiplies their points of contact with the walls of the veins and lymphatics, whence result their imbibition and diffusion into the general circulation."

But, discuss any therapeutical agent as we may, there is something still peculiar to each that evades expression by tongue or pen. Of what use is it to describe odors, tastes, sensations, sights, and sounds? They can only be comprehended by smelling, tasting, feeling, seeing, and hearing. Just so with the peculiar calm, soothing, restful, light feeling that so often results from massage, which can not be understood until experienced. It doubtless arises to a great extent from the pressure of natural worn-out *débris* being speedily removed from off terminal nerve-filaments. Furthermore, massage excites and awakens the *muscular sense* in an agreeable and beneficial manner such as nothing else does, and we know that the state of our muscles indicates and often determines our feeling of health and vigor, or of

weariness and feebleness. To many minds a more satisfactory way of explaining the phenomena produced by massage would be by saying that they all occur in consequence of "magnetism," by which they have an indefinite understanding that this is some sort of imperceptible, ethereal fluid passing from one person to another. Such an explanation is low, gross, and vulgar, and it is erroneously used as a synonym for personal influence by people who do not know the proper scientific meaning of magnetism. Those who claim to have a vast stock of "magnetism" are like those who talk much of their bravery —sensible people find them devoid of either.

LITERATURE AND SCIENCE.*

By MATTHEW ARNOLD.

"NO wisdom, nor counsel, nor understanding, against the Eternal!" says the Wise Man. Against the natural and appointed course of things there is no contending. Ten years ago I remarked on the gloomy prospect for letters in this country, inasmuch as while the aristocratic class, according to a famous dictum of Lord Beaconsfield, was totally indifferent to letters, the friends of physical science, on the other hand, a growing and popular body, were in active revolt against them. To deprive letters of the too great place they had hitherto filled in men's estimation, and to substitute other studies for them, was now the object, I observed, of a sort of crusade with the friends of physical science—a busy host, important in itself, important because of the gifted leaders who march at its head, important from its strong and increasing hold upon public favor.

I could not help, I then went on to say, I could not help being moved with a desire to plead with the friends of physical science on behalf of letters, and in deprecation of the slight which they put upon them. But from giving effect to this desire I was at that time drawn off by more pressing matters. Ten years have passed, and the prospects of any pleader for letters have certainly not mended. If the friends of physical science were in the morning sunshine of popular favor even then, they stand now in its meridian radiance. Sir Josiah Mason founds a college at Birmingham to exclude "mere literary instruction and education"; and at its opening a brilliant and charming debater, Professor Huxley, is brought down to pronounce their funeral oration. Mr. Bright, in his zeal for the United States, exhorts young people to drink deep of "Hiawatha"; and the "Times"—which takes the gloomiest view possible of the future of letters, and thinks that

* Address delivered as "The Rede Lecture" at Cambridge.

a hundred years hence there will only be a few eccentrics reading letters, and almost every one will be studying the natural sciences—the "Times," instead of counseling Mr. Bright's young people rather to drink deep of Homer, is for giving them, above all, "the works of Darwin and Lyell and Bell and Huxley," and for nourishing them upon the voyage of the Challenger. Stranger still, a brilliant man of letters in France, M. Renan, assigns the same date of a hundred years hence as the date by which the historical and critical studies, in which his life has been passed and his reputation made, will have fallen into neglect, and deservedly so fallen. It is the regret of his life, M. Renan tells us, that he did not himself originally pursue the natural sciences, in which he might have forestalled Darwin in his discoveries.

What does it avail, in presence of all this, that we find one of your own prophets, Bishop Thirlwall, telling his brother who was sending a son to be educated abroad that he might be out of the way of Latin and Greek, "I do not think that the most perfect knowledge of every language now spoken under the sun could compensate for the want of them"? What does it avail, even, that an august lover of science, the great Goethe, should have said, "I wish all success to those who are for preserving to the literature of Greece and Rome its predominant place in education"? Goethe was a wise man, but the irresistible current of things was not then manifest as it is now. "No wisdom, nor counsel, nor understanding, against the Eternal!"

But to resign one's self too passively to supposed designs of the Eternal is fatalism. Perhaps they are not really designs of the Eternal at all, but designs—let us for example say—of Mr. Herbert Spencer. Still the design of abasing what is called "mere literary instruction and education," and of exalting what is called "sound, extensive, and practical scientific knowledge," is a very positive design and makes great progress. The universities are by no means outside its scope. At the recent congress in Sheffield of elementary teachers—a very able and important body of men whose movements I naturally follow with strong interest—at Sheffield one of the principal speakers proposed that the elementary teachers and the universities should come together on the common ground of natural science. On the ground of the dead languages, he said, they could not possibly come together; but, if the universities would take natural science for their chosen and chief ground instead, they easily might. Mohammed was to go to the mountain, as there was no chance of the mountain's being able to go to Mohammed.

The vice-chancellor has done me the honor to invite me to address you here to-day, although I am not a member of this great university. Your liberally conceived use of Sir Robert Rede's lecture leaves you free in the choice of a person to deliver the lecture founded by him, and on the present occasion the vice-chancellor has gone for a lecturer

to the sister university. I will venture to say that to an honor of this kind from the University of Cambridge no one on earth can be so sensible as a member of the University of Oxford. The two universities are unlike anything else in the world, and they are very like one another. Neither of them is inclined to go hastily into raptures over her own living offspring or over her sister's; each of them is peculiarly sensitive to the good opinion of the other. Nevertheless they have their points of dissimilarity. One such point, in particular, can not fail to arrest notice. Both universities have told powerfully upon the mind and life of the nation. But the University of Oxford, of which I am a member, and to which I am deeply and affectionally attached, has produced great men, indeed, but has, above all, been the source or the center of great movements. We will not now go back to the middle ages; we will keep within the range of what is called modern history. Within this range, we have the great movements of Royalism, Wesleyanism, Tractarianism, Ritualism, all of them having their source or their center in Oxford. You have nothing of the kind. The movement taking its name from Charles Simeon is far, far less considerable than the movement taking its name from John Wesley. The movement attempted by the Latitude men in the seventeenth century is next to nothing as a movement; the men are everything. And this is, in truth, your great, your surpassing distinction; not your movements, but your men. From Bacon to Byron, what a splendid roll of great names you can point to! We, at Oxford, can show nothing equal to it. Yours is the university not of great movements, but of great men. Our experience at Oxford disposes us, perhaps, to treat movements, whether our own, or extraneous movements such as the present movement for revolutionizing education, with too much respect. That disposition finds a corrective here. Masses make movements, individualities explode them. On mankind in the mass, a movement, once started, is apt to impose itself by routine; it is through the insight, the independence, the self-confidence of powerful single minds that its yoke is shaken off. In this university of great names, whoever wishes not to be demoralized by a movement comes into the right air for being stimulated to pluck up his courage and to examine what stuff movements are really made of.

Inspirited, then, by this tonic air in which I find myself speaking, I am boldly going to ask whether the present movement for ousting letters from their old predominance in education, and for transferring the predominance in education to the natural sciences, whether this brisk and flourishing movement ought to prevail, and whether it is likely that in the end it really will prevail. My own studies have been almost wholly in letters, and my visits to the field of the natural sciences have been very slight and inadequate, although those sciences strongly move my curiosity. A man of letters, it will perhaps be

said, is quite incompetent to discuss the comparative merits of letters and natural science as means of education. His incompetence, however, if he attempts the discussion but is really incompetent for it, will be abundantly visible ; nobody will be taken in ; he will have plenty of sharp observers and critics to save mankind from that danger. But the line I am going to follow is, as you will soon discover, so extremely simple that perhaps it may be followed without failure even by one who for a more ambitious line of discussion would be quite incompetent.

Some of you may have met with a phrase of mine which has been the object of a good deal of comment ; an observation to the effect that in our culture, the aim being to know ourselves and the world, we have, as the means to this end, to know the best which has been thought and said in the world. Professor Huxley, in his discourse at the opening of Sir Josiah Mason's college, laying hold of this phrase, expanded it by quoting some more words of mine, which are these: "Europe is to be regarded as now being, for intellectual and spiritual purposes, one great confederation, bound to a joint action and working to a common result ; and whose members have for their common outfit a knowledge of Greek, Roman, and Eastern antiquity, and of one another. Special local and temporary advantages being put out of account, that modern nation will, in the intellectual and spiritual sphere, make most progress which most thoroughly carries out this programme."

Now on my phrase, thus enlarged, Professor Huxley remarks that I assert literature to contain the materials which suffice for making us know ourselves and the world. But it is not by any means clear, says he, that, after having learned all which ancient and modern literatures have to tell us, we have laid a sufficiently broad and deep foundation for that criticism of life which constitutes culture. On the contrary, Professor Huxley declares that he finds himself "wholly unable to admit that either nations or individuals will really advance, if their common outfit draws nothing from the stores of physical science. An army without weapons of precision and with no particular base of operations might more hopefully enter upon a campaign on the Rhine than a man devoid of a knowledge of what physical science has done in the last century upon a criticism of life."

This shows how needful it is, for those who are to discuss a matter together, to have a common understanding as to the sense of the terms they employ—how needful, and how difficult. What Professor Huxley says implies just the reproach which is so often brought against the study of *belles-lettres*, as they are called : that the study is an elegant one, but slight and ineffectual ; a smattering of Greek and Latin and other ornamental things, of little use for any one whose object is to get at truth. So, too, M. Renan talks of the "superficial humanism"

of a school-course which treats us as if we were all going to be poets, writers, orators, and he opposes this humanism to positive science, or the critical search after truth. And there is always a tendency, in those who are remonstrating against the predominance of letters in education, to understand by letters *belles-lettres*, and by *belles-lettres* a superficial humanism, the opposite of science or true knowledge.

But when we talk of knowing Greek and Roman antiquity, for instance, which is what people have called humanism, we mean a knowledge which is something more than a superficial humanism, mainly decorative. "I call all teaching *scientific*," says Wolf, the critic of Homer, "which is systematically laid out and followed up to its original sources. For example: a knowledge of classical antiquity is scientific when the remains of classical antiquity are correctly studied in the original languages." There can be no doubt that Wolf is perfectly right, that all learning is scientific which is systematically laid out and followed up to its original sources, and that a genuine humanism is scientific.

When I speak of knowing Greek and Roman antiquity, therefore, as a help to knowing ourselves and the world, I mean more than a knowledge of so much vocabulary, so much grammar, so many portions of authors, in the Greek and Latin languages. I mean knowing the Greeks and Romans, and their life and genius, and what they were and did in the world; what we get from them, and what is its value. That, at least, is the ideal; and, when we talk of endeavoring to know Greek and Roman antiquity as a help to knowing ourselves and the world, we mean endeavoring so to know them as to satisfy this ideal, however much we may still fall short of it.

The same as to knowing our own and other modern nations, with the aim of getting to understand ourselves and the world. To know the best that has been thought and said by the modern nations is to know, says Professor Huxley, "only what modern *literatures* have to tell us; it is the criticism of life contained in modern literature." And yet "the distinctive character of our times," he urges, "lies in the vast and constantly increasing part which is played by natural knowledge." And how, therefore, can a man, devoid of knowledge of what physical science has done in the last century, enter hopefully upon a criticism of modern life?

Let us, I say, be agreed about the meaning of the terms we are using. I talk of knowing the best which has been thought and uttered in the world; Professor Huxley says this means knowing *literature*. Literature is a large word; it may mean everything written with letters or printed in a book. Euclid's "Elements" and Newton's "Principia" are thus literature. All knowledge that reaches us through books is literature. But by literature Professor Huxley means *belles-lettres*. He means to make me say that knowing the best which has been thought and said by the modern nations is knowing their *belles-*

lettres and no more. And this is no sufficient equipment, he argues, for a criticism of modern life. But as I do not mean, by knowing ancient Rome, knowing merely more or less of Latin *belles-lettres*, and taking no account of Rome's military and political and legal and administrative work in the world; and as, by knowing ancient Greece, I understand knowing her as the giver of Greek art, and the guide to a free and right use of reason and to scientific method, and the founder of our mathematics and physics and astronomy and biology—I understand knowing her as all this, and not merely knowing certain Greek poems, histories, and speeches—so as to the knowledge of modern nations also. By knowing modern nations, I mean not merely knowing their *belles-lettres*, but knowing also what has been done by such men as Copernicus, Galileo, Newton, Darwin. "Our ancestors learned," says Professor Huxley, "that the earth is the center of the visible universe, and that man is the cynosure of things terrestrial; and more especially was it inculcated that the course of nature had no fixed order, but that it could be, and constantly was, altered." But for us now, says Professor Huxley, "the notions of the beginning and the end of the world entertained by our forefathers are no longer credible. It is very certain that the earth is not the chief body in the material universe, and that the world is not subordinated to man's use. It is even more certain that nature is the expression of a definite order, with which nothing interferes. . . . And yet," he cries, "the purely classical education advocated by the representatives of the humanists in our day gives no inkling of all this!"

In due place and time we will, perhaps, touch upon the question of classical education, but at present the question is as to what is meant by knowing the best which modern nations have thought and said. It is not knowing their *belles-lettres* merely that is meant. To know Italian *belles-lettres* is not to know Italy, and to know English *belles-lettres* is not to know England. Into knowing Italy and England there comes a great deal more, Galileo and Newton among it. The reproach of being a superficial humanism, a tincture of *belles-lettres*, may attach rightly enough to some other disciplines; but, to the particular discipline recommended when I proposed knowing the best that has been thought and said in the world, it does not apply. In that best I certainly include what in modern times has been thought and said by the great observers and knowers of nature.

There is, therefore, really no question between Professor Huxley and me as to whether knowing the results of the scientific study of nature is not required as a part of our culture, as well as knowing the products of literature and art. But to follow the processes by which those results are reached ought, say the friends of physical science, to be made the staple of education for the bulk of mankind. And here there does arise a question between those whom Professor Huxley calls with playful sarcasm "the Levites of culture" and those

whom the poor humanist is sometimes apt to regard as its Nebuchadnezzars.

The great results of the scientific investigation of nature we are agreed upon knowing, but how much of our study are we bound to give to the processes by which those results are reached? The results have their visible bearing on human life. But all the processes, too, all the items of fact, by which those results are established, are interesting. All knowledge is interesting to a wise man, and the knowledge of nature is interesting to all men. It is very interesting to know that from the albuminous white of the egg the chick in the egg gets the materials for its flesh, bones, blood, and feathers, while from the fatty yolk of the egg it gets the heat and energy which enable it at length to break its shell and begin the world. It is less interesting, perhaps, but still it is interesting, to know that, when a taper burns, the wax is converted into carbonic acid and water. Moreover, it is quite true that the habit of dealing with facts which is given by the study of nature is, as the friends of physical science praise it for being, an excellent discipline. The appeal is to observation and experiment; not only is it said that the thing is so, but we can be made to see that it is so. Not only does a man tell us that, when a taper burns, the wax is converted into carbonic acid and water, as a man may tell us, if he likes, that Charon is in his boat on the Styx, or that Victor Hugo is a truly great poet, but we are made to see that the conversion into carbonic acid and water does really happen. This reality of natural knowledge it is which makes the friends of physical science contrast it, as a knowledge of things, with the humanist's knowledge, which is, say they, a knowledge of words. And hence Professor Huxley is moved to lay it down that, "for the purpose of attaining real culture, an exclusively scientific education is at least as effectual as an exclusively literary education." And a certain president of the Section for Mechanical Science in the British Association is, in Scripture phrase, "very bold," and declares that, if a man, in his education, "has substituted literature and history for natural science, he has chosen the less useful alternative." Whether we go these lengths or not, we must all admit that in natural science the habit gained of dealing with facts is a most valuable discipline, and that every one should have some experience of it.

But it is proposed to make the training in natural science the main part of education, for the great majority of mankind at any rate. And here, I confess, I part company with the friends of physical science, with whom up to this point I have been agreeing. In differing from them, however, I wish to proceed with the utmost caution and diffidence. The smallness of my acquaintance with the disciplines of natural science is ever before my mind, and I am fearful of doing them injustice. The ability of the partisans of natural science makes them formidable persons to contradict. The tone of tentative

inquiry, which befits a being of dim faculties and bounded knowledge, is the tone I would wish to take and not to depart from. At present it seems to me that those who are for giving to natural knowledge, as they call it, the chief place in the education of the majority of mankind leave one important thing out of their account—the constitution of human nature. But I put this forward on the strength of some facts not at all recondite, very far from it; facts capable of being stated in the simplest possible fashion, and to which, if I so state them, the man of science will, I am sure, be willing to allow their due weight.

Deny the facts altogether, I think, he hardly can. He can hardly deny that, when we set ourselves to enumerate the powers which go to the building up of human life, and say that they are the power of conduct, the power of intellect and knowledge, the power of beauty, and the power of social life and manners—he can hardly deny that this scheme, though drawn in rough and plain lines, and not pretending to scientific exactness, does yet give a fairly true account of the matter. Human nature is built up by these powers; we have the need for them all. This is evident enough, and the friends of physical science will admit it. But, perhaps, they may not have sufficiently observed another thing, namely, that these powers just mentioned are not isolated, but there is in the generality of mankind a perpetual tendency to relate them one to another in divers ways. With one such way of relating them I am particularly concerned here. Following our instinct for intellect and knowledge, we acquire pieces of knowledge; and presently, in the generality of men, there arises the desire to relate these pieces of knowledge to our sense for conduct, to our sense for beauty, and there are weariness and dissatisfaction if the desire is balked. Now, in this desire lies, I think, the strength of that hold which letters have upon us.

All knowledge is, as I said just now, interesting; and even items of knowledge which from the nature of the case can not well be related, but must stand isolated in our thoughts, have their interest. Even lists of exceptions have their interest. If we are studying Greek accents, it is interesting to know that *pais* and *pas*, and some other monosyllables of the same form of declension, do not take the circumflex upon the last syllable of the genitive plural, but vary, in this respect, from the common rule. If we are studying physiology, it is interesting to know that the pulmonary artery carries dark blood, and the pulmonary vein carries bright blood, departing in this respect from the common rule for the division of labor between the veins and the arteries. But every one knows how we seek naturally to combine the pieces of our knowledge together, to bring them under general rules, to relate them to principles; and how unsatisfactory and tiresome it would be to go on for ever learning lists of exceptions, or accumulating items of fact which must stand isolated.

Well, that same need of relating our knowledge which operates here within the sphere of our knowledge itself, we shall find operating, also, outside that sphere. We feel, as we go on learning and knowing, the vast majority of mankind feel, the need of relating what we have learned and known to the sense which we have in us for conduct, to the sense which we have in us for beauty.

The prophetess Diotima explained to Socrates that love is, in fact, nothing but the desire in men that good should be for ever present to them. This primordial desire it is, I suppose—this desire in men that good should be for ever present to them—which causes in us the instinct for relating our knowledge to our sense for conduct and to our sense for beauty. At any rate, with men in general the instinct exists. Such is human nature. Such is human nature; and, in seeking to gratify the instinct, we are following the instinct of self-preservation in humanity.

Knowledges which can not be directly related to the sense for beauty, to the sense for conduct, are instrument-knowledges; they lead on to other knowledge, which can. A man who passes his life in instrument-knowledges is a specialist. They may be invaluable as instruments to something beyond, for those who have the gift thus to employ them; and they may be disciplines in themselves wherein it is useful to every one to have some schooling. But it is inconceivable that the generality of men should pass all their mental life with Greek accents or with formal logic. My friend Professor Sylvester, who holds transcendental doctrines as to the virtue of mathematics, is far away in America; and, therefore, if in the Cambridge Senate-House one may say such a thing without profaneness, I will hazard the opinion that, for the majority of mankind, a little mathematics, also, goes a long way. Of course, this is quite consistent with their being of immense importance as an instrument to something else; but it is the few who have the aptitude for thus using them, not the bulk of mankind.

The natural sciences do not stand on the same footing with these instrument-knowledges. Experience shows us that the generality of men will find more interest in learning that, when a taper burns, the wax is converted into carbonic acid and water, or in learning the explanation of the phenomenon of dew, or in learning how the circulation of the blood is carried on, than they find in learning that the genitive plural of *pais* and *pas* does not take the circumflex on the termination. And one piece of natural knowledge is added to another, and others to that, and at last we come to propositions so interesting as the proposition that "our ancestor was a hairy quadruped furnished with a tail and pointed ears, probably arboreal in his habits." Or we come to propositions of such reach and importance as those which Professor Huxley brings us, when he says that the notions of our forefathers about the beginning and the end of the world were all wrong,

and that nature is the expression of a definite order with which nothing interferes.

Interesting, indeed, these results of science are, important they are, and we should all be acquainted with them. But what I now wish you to mark is, that we are still, when they are propounded to us and we receive them, we are still in the sphere of intellect and knowledge. And for the generality of men there will be found, I say, to arise, when they have duly taken in the proposition that their ancestor was "a hairy quadruped furnished with a tail and pointed ears, probably arboreal in his habits," there will be found to arise an invincible desire to relate this proposition to the sense within them for conduct and to the sense for beauty. But this the men of science will not do for us, and will hardly, even, profess to do. They will give us other pieces of knowledge, other facts, about other animals and their ancestors, or about plants, or about stones, or about stars; and they may finally bring us to those "general conceptions of the universe which have been forced upon us," says Professor Huxley, "by physical science." But still it will be knowledge only which they give us; knowledge not put for us into relation with our sense for conduct, our sense for beauty, and touched with emotion by being so put; not thus put for us, and therefore, to the majority of mankind, after a certain while, unsatisfying, wearying.

Not to the born naturalist, I admit. But what do we mean by a born naturalist? We mean a man in whom the zeal for observing nature is so strong and eminent that it marks him off from the bulk of mankind. Such a man will pass his life happily in collecting natural knowledge and reasoning upon it, and will ask for nothing, or hardly anything, more. I have heard it said that the sagacious and admirable naturalist whom we have lately lost, Mr. Darwin, once owned to a friend that for his part he did not experience the necessity for two things which most men find so necessary to them—poetry and religion; science and the domestic affections, he thought, were enough. To a born naturalist, I can well understand that this should seem so. So absorbing is his occupation with nature, so strong his love for his occupation, that he goes on acquiring natural knowledge and reasoning upon it, and has little time or inclination for thinking about getting it related to the desire in man for conduct, the desire in man for beauty. He relates it to them for himself as he goes along, so far as he feels the need; and he draws from the domestic affections all the additional solace necessary. But then Darwins are very rare. Another great and admirable master of natural knowledge, Faraday, was a Sandemanian. That is to say, he related his knowledge to his instinct for conduct and to his instinct for beauty by the aid of that respectable Scottish sectary, Robert Sandeman. And, for one man among us with the disposition to do as Darwin did in this respect, there are fifty, probably, with the disposition to do as Faraday.

Professor Huxley holds up to scorn mediæval education, with its neglect of the knowledge of nature, its poverty of literary studies, its formal logic devoted to "showing how and why that which the Church said was true must be true." But the great mediæval universities were not brought into being, we may be sure, by the zeal for giving a jejune and contemptible education. Kings have been our nursing fathers, and queens have been our nursing mothers, but not for this. Our universities came into being because the supposed knowledge delivered by Scripture and the Church so deeply engaged men's hearts, and so simply, easily, and powerfully related itself to the desire for conduct, the desire for beauty—the general desire in men, as Diotima said, that good should be for ever present to them. All other knowledge was dominated by this supposed knowledge and was subordinated to it, because of the surpassing strength of the hold which it gained upon men's affections by allying itself profoundly with their sense for conduct and their sense for beauty.

But now, says Professor Huxley, conceptions of the universe fatal to the notions held by our forefathers have been forced upon us by physical science. Grant to him that they are thus fatal, that they must and will become current everywhere, and that every one will finally perceive them to be fatal to the beliefs of our forefathers. The need of humane letters, as they are truly called, because they serve the paramount desire in men that good should be for ever present to them—the need of humane letters to establish a relation between the new conceptions and our instinct for beauty, our instinct for conduct, is only the more visible. The middle age could do without humane letters, as it could do without the study of nature, because its supposed knowledge was made to engage its emotions so powerfully. Grant that the supposed knowledge disappears, its power of being made to engage the emotions will of course disappear along with it—but the emotions will remain. Now, if we find by experience that humane letters have an undeniable power of engaging the emotions, the importance of humane letters in man's training becomes not less, but greater, in proportion to the success of science in extirpating what it calls "mediæval thinking."

Have humane letters, have poetry and eloquence, the power here attributed to them of engaging the emotions, and how do they exercise it? and, if they have it and exercise it, how do they exercise it in relating the results of natural science to man's sense for conduct, his sense for beauty? All these questions may be asked. First, have poetry and eloquence the power of calling out the emotions? The appeal is to experience. Experience shows us that for the vast majority of men, for mankind in general, they have the power. Next, how do they exercise it? And this is perhaps a case for applying the Preacher's words: "Though a man labor to seek it out, yet he shall not find it; yea, further, though a wise man think to know it, yet

shall he not be able to find it." Why should it be one thing, in its effect upon the emotions, to say, "Patience is a virtue," and quite another thing, in its effect upon the emotions, to say with Homer,

τλητὸν γὰρ Μοῖραι θυμὸν θέσαν ἀνθρώποισιν *—

"for an enduring heart have the destinies appointed to the children of men"? Why should it be one thing, in its effect upon the emotions, to say with Spinoza, *Felicitas in eo consistit quod homo suum esse conservare potest*—"Man's happiness consists in his being able to preserve his own essence," and quite another thing, in its effect upon the emotions, to say, "What is a man advantaged, if he gain the whole world and lose himself, forfeit himself?" How does this difference of effect arise? I can not tell, and I am not much concerned to know; the important thing is that it does arise, and that we can profit by it. But how, finally, are poetry and eloquence to exercise the power of relating the results of natural science to man's instinct for conduct, his instinct for beauty? And here again I answer that I do not know how they will exercise it, but that they can and will exercise it I am sure. I do not mean that modern philosophical poets and modern philosophical moralists are to relate for us the results of modern scientific research to our need for conduct, our need for beauty. I mean that we shall find, as a matter of experience, if we know the best that has been thought and uttered in the world, we shall find that the art and poetry and eloquence of men who lived, perhaps, long ago, who had the most limited natural knowledge, who had the most erroneous conceptions about many important matters, we shall find that they have, in fact, not only the power of refreshing and delighting us, they have also the power—such are the strength and worth, in essentials, of their author's criticism of life—they have a fortifying and elevating and quickening and suggestive power capable of wonderfully helping us to relate the results of modern science to our need for conduct, our need for beauty. Homer's conceptions of the physical universe were, I imagine, grotesque; but really, under the shock of hearing from modern science that "the world is not subordinated to man's use, and that man is not the cynosure of things terrestrial," I could desire no better comfort than Homer's line which I quoted just now:

τλητὸν γὰρ Μοῖραι θυμὸν θέσαν ἀνθρώποισιν—

"for an enduring heart have the destinies appointed to the children of men."

And the more that men's minds are cleared, the more that the results of science are frankly accepted, the more that poetry and eloquence come to be studied as what they really are—the criticism of life by gifted men, alive and active with extraordinary power at an unusual number of points—so much the more will the value of humane letters, and of art also, which is an utterance having a like kind of

* "Iliad," xxiv, 49.

power with theirs, be felt and acknowledged, and their place in education be secured.

Let us, all of us, avoid as much as possible any invidious comparison between the merits of humane letters, as means of education, and the merits of the natural sciences. But when some President of a Section for Mechanical Science insists on making the comparison, and tells us that "he who in his training has substituted literature and history for natural science has chosen the less useful alternative," let us say to him that the student of humane letters only will at least know also the great general conceptions brought in by modern physical science; for science, as Professor Huxley says, forces them upon us all. But the student of the natural sciences only will, by our very hypothesis, know nothing of humane letters; not to mention that in setting himself to be perpetually accumulating natural knowledge, he sets himself to do what only specialists have the gift for doing genially. And so he will be unsatisfied, or at any rate incomplete, and even more incomplete, than the student of humane letters.

I once mentioned in a school-report how a young man in a training college, having to paraphrase the passage in "Macbeth" beginning,

"Canst thou not minister to a mind diseased?"

turned this line into, "Can you not wait upon the lunatic?" And I remarked what a curious state of things it would be if every pupil of our primary schools knew that, when a taper burns, the wax is converted into carbonic acid and water, and thought at the same time that a good paraphrase for

"Canst thou not minister to a mind diseased?"

was, "Can you not wait upon the lunatic?" If one is driven to choose, I think I would rather have a young person ignorant about the converted wax, but aware that "Can you not wait upon the lunatic?" is bad, than a young person whose education had left things the other way.

Or to go higher than the pupils of our primary schools. I have in my mind's eye a member of Parliament who goes to travel in America, who relates his travels, and who shows a really masterly knowledge of the geology of the country and of its mining capabilities, but who ends by gravely suggesting that the United States should borrow a prince from our royal family and should make him their king, and should create a House of Lords of great landed proprietors after the pattern of ours; and then America, he thinks, would have her future happily secured. Surely, in this case, the President of the Section for Mechanical Science would himself hardly say that our member of Parliament, by concentrating himself upon geology and mining and so on, and not attending to literature and history, had "chosen the more useful alternative."

If, then, there are to be separation and option between humane let-

ters on the one hand and the natural sciences on the other, the great majority of mankind, all who have not exceptional and overpowering aptitudes for the study of nature, would do well, I can not but think, to choose to be educated in humane letters rather than in the natural sciences. Letters will call out their being at more points, will make them live more.

And indeed, to say the truth, I can not really think that humane letters are in danger of being thrust out from their leading place in education, in spite of the array of authorities against them at this moment. So long as human nature is what it is, their attractions will remain irresistible. They will be studied more rationally, but they will not lose their place. What will happen will rather be that there will be crowded into education other matters besides, far too many; there will be, perhaps, a period of unsettlement and confusion and false tendency; but letters will not in the end lose their leading place. If they lose it for a time, they will get it back again. We shall be brought back to them by our wants and aspirations. And a poor humanist may possess his soul in patience, neither strive nor cry, admit the energy and brilliancy of the partisans of physical science, and their present favor with the public, to be far greater than his own, and still have a happy faith that the nature of things works silently on behalf of the studies which he loves, and that, while we shall all have to acquaint ourselves with the great results reached by modern science, and to give ourselves as much training in its disciplines as we can conveniently carry, yet the majority of men will always require humane letters, and so much the more as they have the more and the greater results of science to relate to the need in man for conduct, and to the need in him for beauty.

And so we have turned in favor of the humanities the "*No wisdom, nor understanding, nor counsel, against the Eternal!*" which seemed against them when we started. The "hairy quadruped furnished with a tail and pointed ears, probably arboreal in his habits," carried hidden in his nature, apparently, something destined to develop into a necessity for humane letters. The time warns me to stop; but most probably, if we went on, we might arrive at the further conclusion that our ancestor carried in his nature, also, a necessity for Greek. The attackers of the established course of study think that against Greek, at any rate, they have irresistible arguments. Literature may perhaps be needed in education, they say; but why on earth should it be Greek literature? Why not French or German? nay, "has not an Englishman models in his own literature of every kind of excellence?" As before, it is not on any weak pleadings of my own that I rely for convincing the gainsayer; it is on the constitution of human nature itself and on the instinct of self-preservation in humanity. The instinct for beauty is set in human nature, as surely as the instinct for

knowledge is set there, or the instinct for conduct. If the instinct for beauty is served by Greek literature as it is served by no other literature, we may trust to the instinct of self-preservation in humanity for keeping Greek as part of our culture. We may trust to it for even making this study more prevalent than it is now. As I said of humane letters in general, Greek will come to be studied more rationally than at present; but it will be increasingly studied as men increasingly feel the need in them for beauty, and how powerfully Greek art and Greek literature can serve this need. Women will again study Greek, as Lady Jane Grey did; perhaps in that chain of forts, with which the fair host of the Amazons is engirdling this university, they are studying it already. *Defuit una mihi symmetria prisca*, said Leonardo da Vinci; and he was an Italian. What must an Englishman feel as to his deficiencies in this respect, as the sense for beauty, whereof symmetry is an essential element, awakens and strengthens within him! what will not one day be his respect and desire for Greece and its *symmetria prisca*, when the scales drop from his eyes as he walks the London streets, and he sees such a lesson in meanness as the Strand, for instance, in its true deformity! But here I have entered Mr. Ruskin's province, and I am well content to leave not only our street architecture, but also letters and Greek, under the care of so distinguished a guardian.—*Nineteenth Century.*

WHAT ARE CLOUDS?

By C. MORFIT.

THOUGH the clouds are such familiar objects, very little is known about them, and the processes by which they are formed and give back their moisture to the earth are unsolved mysteries.

They can not be classified as belonging to the solid, fluid, or gaseous form of matter. Yet they are defined as being "a collection of watery particles in the state of *vapor*, suspended in the air." If they are ordinary vapor, they must be governed by the laws which affect vapors. Brande defines *vapor* thus: "When liquids and certain solids are heated, they become converted into elastic fluids or vapors, which differ from gases in this respect, that they are not under common circumstances permanently elastic, but resume the liquid or solid form when cooled down to ordinary temperature." According to this definition, clouds can not be composed of *ordinary* vapor, for under all conditions their temperature must be below the condensing point of water-vapor.

At the elevations at which clouds are often seen, they are in the regions of perpetual congelation; and as they float above the highest

mountains they must be exposed, even in the sunshine, and certainly in the night, when the solar heat is not poured upon them, to temperatures colder than those of the frigid zones.

As they occur in all climates, over the poles as well as at the equator, and even in the warm latitudes at elevations which are above the regions of unmelted snows, it must be assumed that a low temperature *alone* does not cause them to give up their moisture in the form of rain or snow.

Glaisher, in entering a cloud eleven hundred feet thick, found the dew-point remained unchanged, showing that there was no more (condensable) moisture in the cloud than in the surrounding air. And aëronauts obtain no dew by Regnault's hygrometer at an elevation of five miles, but clouds float above that height.

The moisture *in the air* must not be confounded with the water of the clouds. This moisture is precipitated by a low temperature, as is seen in the condensation of water on the *outside* of a glass of ice-water on a warm day, and the coating of the *inside* of window-panes with ice on a very cold one; and the formation of dews in summer and of frosts in winter.

The precipitation of the moisture from clouds must be caused by some peculiar condition of the clouds themselves. After a rain there often are as many clouds remaining or passing away as there were at the commencement of or at any time during the rain. In this there is evidence that the action going on in a part of a single cloud, or in special clouds, does not extend over the whole mass, nor to other clouds near by.

In countries where it seldom or never rains, or where the rains are periodic, clouds are as common as in places where it rains often. From this it appears that the causes which produce precipitation are entirely suspended, or rather do not exist in certain localities and seasons, although clouds abound there at the time.

Another fact worthy of consideration is that snow and rain fall slowly, little by little, and not in one sudden down-pour, as would be the case if the whole mass of cloud or clouds were brought at the same instant under the action which produces rain or snow.

It must not be forgotten that clouds move in well-defined masses, sometimes retaining their shape for a long time, and do not disappear in the air, as they would do if they were ordinary water-vapor.

As it is difficult to reach the clouds, little has been learned of their composition. But at the elevated stations of the meteorological departments of the various nations where the observers are at times in the midst of clouds, opportunities may occur for observation and examination of them, which will reveal the laws by which they are governed. It is not too much to expect that the acute and practical minds of the present age will, ere long, add much to our present scant knowledge of these mysterious *meteors*.

THE PAST AND PRESENT OF THE CUTTLE-FISHES.*

By Dr. ANDREW WILSON.

FEW groups of the animal kingdom possess a greater interest, either for the zoölogist or for the general investigator, than that selected as the subject of the present article. From the earliest ages in which human curiosity concerning external nature began to develop into scientific observation, the cuttle-fishes have formed subject-matter of remark. In the writings of the classic naturalists they receive a due meed of attention. Their peculiarities of form and habits attracted the notice of Aristotle and Pliny; and even their development, in its more readily observed phases, was studied in the days when biology was but an infantile science. Tracing the lines of cuttle-fish lore onward through the centuries of growing culture, we discern the mediæval spirit of exaggeration and myth seizing upon the group as a likely subject for enlargement and discussion. In the fabu-

Fig. 1.—Cuttle-fishes swimming.

lous history and "folk-lore" of zoölogy, the cuttle-fishes have over and over again played a more than prominent part. In the days of their mythical history they have swallowed whole fleets of ships; they have been credited more than once with the destruction of even an armored navy; and on more than one occasion there can be little doubt that they have played the parts of Sindbad's floating island, and of the "great unknown," the sea-serpent itself. To the modern zoölogist, however, eager in his search after the causes which have wrought out the existing order of animal nature, the cuttle-fishes present themselves as an unusually interesting group.

* Abridged from "Belgravia."

The definition of the *Cephalopoda*, or cuttle-fish class, is largely a matter of commonplace observation. Linnæus, naming them "cephalopods," or "head-footed" mollusks, indicated the structural feature which was calculated to appeal most plainly even to non-technical minds. The circlet of arms, feet, or tentacles crowning the head-extremity of a cuttle-fish, thus presents us with a personal character of unmistakable nature. It is necessary, however, to bear in mind that the ordinary and, to a certain extent, natural fashion of representing a cuttle-fish head upward is, in zoölogical eyes, a complete reversion of its surfaces. To understand clearly why to speak of a cuttle-fish head as its *lower*, and of its tail as its *upper* extremity, is a correct zoölogical designation, we must enter upon a comparison of the cuttle-fish body with the forms of its neighbor mollusks. The contemplation of such a familiar being as a snail or whelk introduces us to a characteristic example of molluscan form and anatomy. The head of the snail or other gasteropod is clearly enough defined; and no less plainly discernible is the enlarged and broadened surface on which the animal walks. This surface is known as the "foot." In one shape or another this "foot" is a characteristic possession of the molluscan tribes. In a section of a mussel or cockle, we perceive the "foot" to exist as a muscular mass developed in the middle line of the body below, and variously used in the mussel class as a spinning organ, a leaping-pole, and a boring apparatus. Here we note the natural development of the foot in the middle line of the animal. Let us suppose this foot to be extended downward, and to be broadened so as to form a surface of progression, and we may conceive readily of the modification whereby a simple foot like that of the mussel becomes developed to form the enlarged disk of the gasteropod. In the latter case we observe that the foot occupies the floor of the body; the bulk of the body, and the head in particular, being borne above.

Cuttle-fish development can be shown to run, so far, in parallel lines to those of the personal evolution of mussel and snail. But divergent paths soon appear in cuttle-fish development; and these variations, while they indicate an ancient departure from the ordinary molluscan type, likewise give to the subjects of our present study their most characteristic features. When a mussel or snail is watched in its earlier stages of development, the embryo is seen, sooner or later, to produce an appendage highly characteristic of molluscan young at large, and named the *velum*. By aid of this ciliated fold such an organism as a young cockle, for instance, swims freely through its native waters. This velum undergoes varied changes and alterations in the after-stages of molluscan development; but, when cuttle-fish development is studied in its fullest details, no velum is found among the possessions of the larval body. Such an omission has naturally been made the subject of remark by naturalists. Some authorities—Grenacher, for instance—have insisted upon the recognition of the

arms of the cuttle-fish head as the representatives of the missing velum. But, as the latter organ always exists on the dorsal or upper side of the mouth, and as the arms are placed originally behind and under the cuttle-fish mouth, the correspondence of arms and velum has not been accepted by zoölogists. On the other side stands out the opinion of Huxley, who regards the "arms" of the cuttle-fish head as more truly corresponding with the "foot" of the mussel, snail, and other mollusks.

The margins of the foot, in this view of matters, have been prolonged in the young cuttle-fish to form eight, ten, or more arms, and the front and sides of the foot, having overgrown the mouth, are united in front, so that the mouth appears to be placed in the center of the foot, instead of in front and above it, as in other mollusks. So, also, most naturalists maintain, and with every appearance of correctness, that the characteristic "funnel" of the cuttle-fishes—to be hereafter referred to—is an organ formed by two side-processes of the foot, named *epipodia*. Adopting the view thus sanctioned by competent authority, we may trace in a cuttle-fish the highly modified form of a snail or whelk, and the still more modified form of the mussel tribes. The foot, instead of growing backward and downward as in the snail, and thus forming a broad walking disk, comes to grow over the mouth in front. So that, placing a cuttle-fish in structural comparison with a whelk or mussel, we should have to set it head downward, when the foot (or arms) would be lowest, and the great bulk of the body, with the heart uppermost, would be situated, as in the snail, above the foot.

The group of the cuttle-fishes may be said to divide itself in the most natural fashion into two main divisions. The first of these groups includes all living cuttle-fishes save one—the pearly nautilus. This first division is that of the *Dibranchiates*, or two-gilled cuttle-fishes. The familiar octopus (Fig. 1), the loligos or squids, the sepias, and the argonauts or paper nautili, are among the best known of its representatives. The second group is represented by a single living cuttle-fish, the pearly nautilus (*Nautilus Pompilius*), just mentioned, and by many fossil and extinct forms.

One of the most remarkable traits of cuttle-fish existence is the curious play of "shot" colors which takes place in their integument. I have seen a loligo, or squid, stranded on the sea-beach make glorious its dying agonies by a play of colors of the most astounding description. The natural purplish tint of the body was now and again deepened to well-nigh a dark blue; the slightest touch served to develop a patch of angry pink; and continually over the whole surface of the body the hues and tints, ranging from dark purple to light red, succeeded each other in rapid array.

The assimilation of an animal's color to the surfaces on which it rests forms a notable circumstance of zoölogy, which has been denom-

inated "mimicry." That cuttle-fishes possess such a power is well known. The hue of an octopus may so closely resemble that of the rock to which it attaches itself, that the observer can with difficulty say which is rock and which is animal. A flounder's color is in the same way assimilated to the sand on which it rests, although in the fish the alteration of color seen in the cuttle-fishes is not represented.

The manner of production of the changes of hue and play of "shot" colors in the cuttle-fishes is really analogous to that whereby the famed chameleons effect their alterations of hue.

The locomotion of the cuttle-fishes forms a point of interest in connection with their general structure and physiology. Any one who has attentively watched the movements of an octopus in its tank must have been struck by the literally acrobatic ease with which it accommodated itself to the exigencies of its life and surroundings. In their lithe, muscular, and flexible arms, the cuttle-fishes possess an apparatus which is equally serviceable for the capture of prey, and for walking mouth downward — that is, in their structurally natural position. They possess, likewise, the power of swimming upper side forward—or popularly stated "backward"—by means of the jets of water which, by forcible contractions of the muscular mantle-sac, are projected from the tube or "funnel" situated on the hinder face of the body. These *jets d'eau* consist of the effete water which has been used in breathing, so that the act of expiration and the effete water of respiration together become utilized, in the economical wisdom of nature, as a means of propulsion. The mysterious backward flight of an octopus through its tank (Fig. 1), when, detaching itself from its hold on the rock, it swims gracefully and swiftly through the water, is effected in the manner just described. This form of hydraulic apparatus, imitated in experiments in marine engineering, serves but to strengthen the wise man's adage concerning the utter lack of novelty in terrestrial and mundane things.

It is equally interesting to note that some of the squids or loligos —named popularly "flying squids"—appear to be able to rise from the surface of the sea and to spring into the air after the fashion of the flying-fishes. Instances are mentioned of the flying squids having occasionally landed themselves on the decks of ships in their atmospheric leaps.

The "arms" or "feet" demand, however, a somewhat detailed mention, on account of their armature. In all cuttle-fishes, save the exceptional pearly nautilus, the arms are either eight or ten in number, and are provided with *acetabula*, or "suckers." Those cuttles in which ten arms are present—and of these the squids and sepias form good examples—have two of these appendages produced beyond the remaining eight in length. The "suckers" (Fig. 2, A), which constitute a most noteworthy armament of the arms, are borne on short

stalks in the ten-armed cuttle-fishes, but are unstalked in the eight-armed species. Each sucker (Fig. 2) exhibits all the structures incidental to an apparatus adapted to secure effective and instantaneous adhesion to any surface. It consists of a horny or cartilaginous cup (*a*), within which are muscular fibers converging toward its center, where they form a well-defined plug or piston (*b*). By the withdrawal of this plug a partial vacuum is produced, and the suckers adhere by atmospheric pressure to the surface on which they are placed. The sucker is released by the projection of the plug and by the consequent destruction of the vacuum. The number of the suckers varies, but is always considerable; and when we reflect that the array of suckers can be instantaneously applied, and that their hold is automatically perfect, the grasp of the cephalopods is seen to be of the most efficient kind. In some cuttle-fishes, and most notably in the so-called "hooked squids" (*Onychoteuthis*), the pistons of the suckers are developed to form powerful hooks, by means of which the prey may be secured with additional facility; and in the common squids the margin of the sucker is provided with a series of minute horny hooks. The "arms" themselves, it need hardly be remarked, are extremely mobile; they are highly muscular, and can be adapted with ease to the varied functions of prehension and movement they are destined to subserve. As regards their arrangement, they are arranged in four pairs—a dorsal and a ventral pair, and two lateral pairs; the two elongated tentacles, when developed, being situated between the third and fourth pairs of arms on the ventral or lower surface.

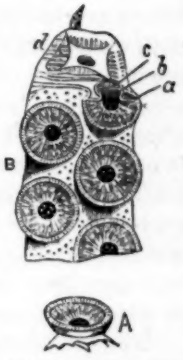

FIG. 2.—SUCKERS OF THE CUTTLE-FISH.

The alimentary tract or digestive system of the cuttle-fish race is in every respect of well-developed and complete character. Lower down in the molluscan series the commissariat department is subserved by a very perfect digestive apparatus, including representatives of most of the organs familiar enough to us in higher or vertebrate existence. In the cephalopods we should naturally expect the standard of lower molluscan organization to be further elaborated; and this anatomical expectation is justified by the actual details of cuttle-fish structure. The mouth opens on the upper surface of the head—a disposition of matters already accounted for when considering the relations of the cuttle-fish body to that of other mollusks. The mouth-opening is usually bounded by a raised lip, and leads into a cavity containing an elaborate apparatus, analogous to the jaws of higher animals, and by means of which the food of these animals is triturated and divided. An inspection of the masticating apparatus of a cuttle-fish readily solves the question, "How are the hard shells of their

crustacean food broken down?" There exists within the mouth, firstly, a hard, horny beak, resembling closely in shape the beak of a parrot, and consisting of two chief divisions, whereof one—the front—is the smaller, and is overlapped by the hinder beak. Set in action by appropriate muscles, these beaks divide the hard parts of the food with the greatest ease. But a second apparatus of more typical nature likewise exists in these animals. This is the *odontophore*, a structure popularly named the "tongue," and which is common to the whelk and snail class, to the sea-butterflies, and to the cuttle-fishes. It consists essentially of an elongated ribbon-like structure, bearing hooked teeth, generally disposed in transverse rows. This apparatus, set in action by special muscles, and worked after the fashion of a chain-saw, is used to rasp down the food; while new growths of its substance from behind serve to repair the loss caused by the friction to which it is subjected.

The gills, as already noted, number two in all cuttle-fishes except the pearly nautilus, and may demand a special notice. Each gill is a conical organ, consisting essentially of a dense net-work of blood-vessels, in which impure blood brought by the great veins is exposed to the action of the oxygen contained in the water which is being continually admitted to the gill-chambers. Each gill is contained within a kind of chamber to which water is admitted by the front edge of the mantle-sac. This opening being closed by a valve against the exit of the water, the forcible contraction of the body-walls ejects the water, as previously described, from the "funnel." The gills are themselves contractile, but they do not possess the armament of minute vibratile processes or *cilia*, so typical of the gills of other mollusca. The need for these cilia as organs providing for the circulation of water over the gill-surfaces is of course removed, in view of the very perfect means existent in the cuttle-fishes for the renewal of the water used in breathing. As a living octopus or other cuttle-fish is watched, the movements of inspiration and expiration are plainly indicated by the expansion and contraction of the body-walls, and they imitate in a singularly exact fashion the analogous movements of the highest animals. Observers have likewise described in certain members of the cuttle-fish class a series of minute pores, by which water enters the great veins and mixes with the blood. It is also certain that water enters the general body cavity and bathes the organs of the animal, thus converting that cavity into a physiologically active space, possessing an influence on the circulation in that its contained water presents a medium for the conveyance of oxygen into, and for the reception of waste materials from, the blood.

Connected on the one hand with the digestive system, and on the other with the more purely glandular structures of the body, is the organ known familiarly as the "ink-bag" of these animals. The cuttle-fishes are well known to utilize the secretion of this sac as a means of

defense, and for enabling them to escape from their enemies. Discharging the inky fluid through the "funnel," into which the duct of the ink-sac opens, it rapidly diffuses itself through the water, and enables the animal to escape under a literal cloak of darkness. The exact nature and relationship of this ink-sac to the other organs of the cuttle-fish have long been disputed. According to one authority, the ink-bag represented the gall-bladder, because in the octopus it is imbedded in the liver. From another point of view, it was declared to represent an intestinal gland; while a third opinion maintained its entirely special nature. The ink-sac is now known to be developed as an offshoot from the digestive tube; and, taking development as the one infallible criterion and test of the nature of living structures, we may conclude that it represents at once a highly specialized part of the digestive tract, and an organ which, unrepresented entirely in the oldest cuttle-fishes, has been developed in obedience to the demands and exigencies of the later growths of the race. It is this ink-sac which is frequently found fossilized in certain extinct cuttle-fish shells. Its secretion forms the original *sepia* color, a term derived from the name of a cuttle-fish genus. The fossilized sepia has been used with good effect when ground down. The late Dean Buckland gave some of this fossil ink to Sir Francis Chantrey, who made with it a drawing of the specimen from which it had been taken; and Cuvier is said to have used this fossilized ink in the preparation of the plates wherewith he illustrated his "Mollusca." At the present time, recent cuttle-fish ink is said to be utilized in the manufacture of ordinary artists' "sepia."

The due regulation of cuttle-fish existence is determined by the action of its nervous apparatus. The ordinary type of molluscan nervous system undergoes in the cuttle-fishes a decided change of form. In a snail or whelk, for example, the nervous system exhibits an arrangement of three chief nerve-masses or "ganglia," connected by nervous cords. Of these three nerve-centers, one is situated in the head, a second in the "foot" or organ of movement, and a third in the neighborhood of heart and gills, or amid the viscera generally. Increased concentration of this type of nerve-arrangement awaits us in cuttle-fish organization. Just as the spider possesses a more concentrated and localized nerve-axis than the insect, or as the gangliated chain of the latter becomes the fused nerve-mass of the spider, so in the cuttle-fish, the molluscan nerve-system, scattered and diffused in the snail, whelk, or mussel, becomes localized in adaptation to the increased nerve-control and to the wider instincts of cuttle-fish existence. This process of nerve-localization and concentration is accompanied by certain important modifications affecting other regions and structures of cuttle-fish economy. Thus the nerve-centers are found to be protected and inclosed within a gristly or cartilaginous case, that foreshadows the functions of the vertebrate skull, though in no sense connected with that structure.

Not the least interesting feature of this localized mass of nervous matter is the fact that it exhibits the same arrangement of gray and white nerve-matter that is seen in the highest brains. An outer gray and an inner white layer are discernible in the nerve-ganglia of cephalopods, as in the cerebrum of man; and, as in the highest animals, the cuttle-fish gray matter is found to consist of nerve-cells, while the white matter is chiefly composed of nerve-fibers. Thus the laws of developmental progress affect the microscopic and intimate structure of the living form as well as the more obvious details of structure. From the main nerve-mass of the cuttle-fishes nerves arise to supply the body at large. Nerves of special sense supply eyes, ears, and olfactory organs; while the viscera and the "mantle" or general body-covering are also well provided with the means of innervation.

Cuttle-fish existence possesses, in all probability, the five "gateways of knowledge," through which the impressions of the outer world are received, and by which these impressions are modified and transmitted to the brain-masses as sensations of sight, hearing, smell, touch, and taste. There is little need to draw upon hypothesis in the assumption that the arms or tentacles are efficient organs of touch in Cephalopoda, or that the structures of the mouth may subserve taste, in so far as the latter sense may be required to satisfy the demands of cuttle-fish existence. An organ of smell is definitely situated behind or above the eyes. There two small projections, or, as frequently, two minute pits or depressions, occur. These pits are ciliated, and between the cilia "olfactory cells" are situated. These cells, in turn, represent the similar structures which occur in higher animals, and which, in man himself, form the characteristic terminations to his olfactory nerves. That the cuttle-fishes can literally scent their prey from afar off is an idea confirmed by the facts of their every-day life.

The "ears" of the cuttle-fishes present us with two sacs—named "auditory sacs"—which may, as in the nautilus, either be attached to the chief nerve-mass itself, or, as in the two-gilled cuttles, be lodged in special cavities in the gristly "skull." A cuttle-fish "ear" is essentially a sac or bag, called an "otocyst," containing either one or many "otoliths" or "ear-stones," suspended in a watery fluid. This, indeed, is the primitive type of "ear" we may find even in the *Medusidæ* or "jelly-fishes" themselves. The ear-sacs of many cuttle-fishes open on the external surface of the body by two fine canals, named "Kölliker's ducts," after their distinguished discoverer. Occasionally these ducts end blindly, and do not open on the body surface. These facts lend additional support to the opinion that in the ear of the cuttle-fish we find primitive structures proper to the ears of vertebrates, the minute canals of Kölliker corresponding with the *recessus vestibuli* of the vertebrate organ of hearing. Once again, therefore, we find the progressive development of cephalopods and vertebrates

running in parallel, but nevertheless in distinct and independent, lines; and this likeness is further strengthened when we discover that not merely the ear, but the eye likewise, of these two groups of animals is formed or developed in an essentially similar fashion. The ear of the cuttle-fish presents us with a permanent example of an early and transitory stage in the development of the vertebrate ear, and a common plan of ear-production is thus seen to traverse a wide extent of the animal world.

The present history of the cuttle-fishes may be concluded by the briefest possible reference to their distribution and classification. Over two thousand species of cephalopods are known. But geology claims the vast majority, only two hundred and eighteen species being included in the ranks of living animals. The cuttle-fishes are very widely distributed in existing seas. They occur in the far north; they are plentifully represented in the colder seas by the squids which form the bait of the Newfoundland cod-fishers; but in tropical regions they attain their greatest size and numerical strength. Their classification is both simple and natural. Their division into *Dibranchiates* ("two-gilled") and *Tetrabranchiates* ("four-gilled") is a method of arrangement which accurately reflects variations in their existing structure, as it correctly indicates the main lines of their geological and past history. Of four-gilled cuttle-fishes there is but one living example—the pearly nautilus (Fig. 3). Its special and distinctive peculiarities may be rapidly summed up in the statement that it has

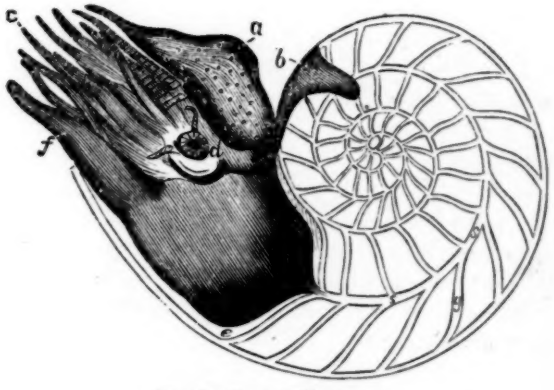

FIG. 3.—PEARLY NAUTILUS.

four gills, numerous arms (*c*), no suckers, no ink-sac, an incompletely tubular funnel (*f*), stalked eyes, and an external, many-chambered shell, in the last formed and largest compartment (*e*) of which the body is lodged.

The absence of an ink-sac in the nautilus is a fact correlated with its bottom-living habits and with the absence of any need or require-

ment for the sudden concealment from enemies which the more active two-gilled forms demand. The many-chambered shell of the pearly nautilus exhibits a flat, symmetrical, spiral shape. Its many-chambered state is explained by the fact that as the animal grows it successively leaves the already formed chambers, and secretes a new chamber to accommodate the increasing size of body. Each new chamber is partitioned off from that last occupied by a shelly wall called a *septum* (*g*). Through the middle of the series of septa runs a tube named the *siphuncle* (*s*, *s*), whose function has been credited with being that of maintaining a low vitality in the disused chambers of the shell.

All other living cuttle-fishes possess, on the contrary, two gills, never more than ten arms provided with suckers, an ink-sac, unstalked eyes, a completely tubular funnel, and an internal shell. If, however, the nautilus represents in its solitary self the four-gilled cuttle-fishes of to-day, it likewise, like "the last of the Mohicans," appears as the descendant of a long line of famous ancestors. In its distribution, the nautilus is limited to the southern seas. It is still the rarest of animals in our museums, although its shells are common enough.

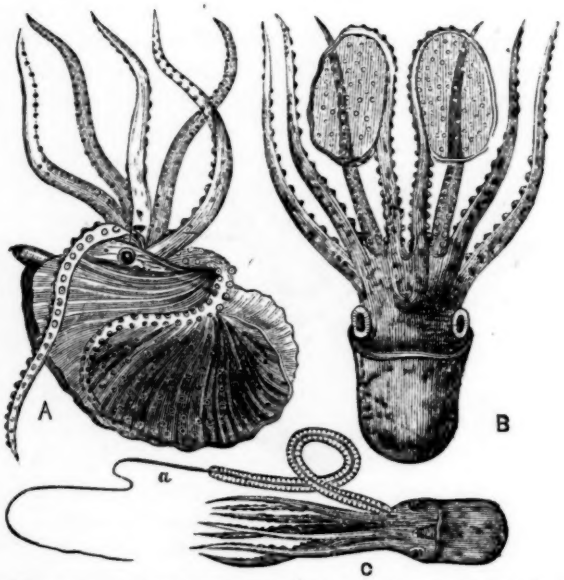

FIG. 4.—PAPER NAUTILUS. A, female argonaut showing shell, around which the two expanded arms are clasped; B, female removed from shell; C, the male argonaut (shell-less).

This, according to Mr. Moseley, is no doubt due to the fact that the animal is mostly an inhabitant of deep water. The shells of *Spirula* (Fig. 6) similarly occur in countless numbers on tropical beaches, yet the animal has only been procured two or three times.

It is thus the pearly nautilus floats under certain circumstances on the surface of the water. The argonaut (Fig. 4), credited in poetry and fiction with this power, never floats on the surface, as was of old believed. It is simply a mundane cuttle-fish, whose two expanded arms are never used as sails, after the popularly supposed fashion, but are employed solely to secrete and attach to the body the false shell (Fig. 4, A) with which it is provided.

Among the two hundred odd living two-gilled cuttle-fishes, considerable diversity of external form may be seen; but the general type

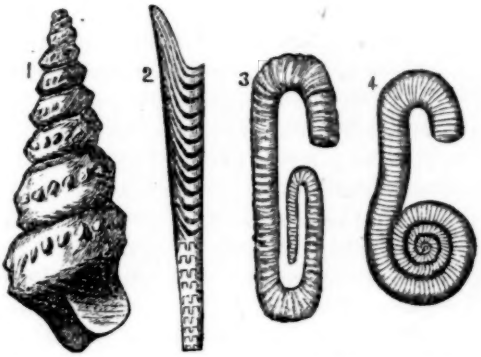

FIG. 5.—SHELLS OF FOSSIL CUTTLE-FISHES. 1, Turrilites; 2, Baculites; 3, Hamites; 4, Scaphites.

already described is at the same time closely adhered to; and save in the case of the paper nautilus or argonaut, in which the characteristic shape of body is concealed by the shell, the cuttle-fish characters are readily apparent. The shell of the paper nautilus (Fig. 4, A) is termed "false" or "pedal," because it is not formed by the mantle, as all true shells are, but by the two expanded arms, as already mentioned. In its homology it therefore coincides with foot-secretions (such as the "beard" of the mussel), and not with the shells of its neighbors. The female argonaut alone possesses a "shell," the male (Fig. 4, c) being a diminutive creature, measuring only an inch or so in length. It is in the ranks of the two-gilled cuttle-fishes that we discover those phases of cuttle-fish life which most characteristically appeal to the popular mind. Thus, many species of two-gilled cuttles are eaten and considered dainties by foreign nations; it is from this group that the sepia color already mentioned is obtained; their internal shells gave us the "pounce" of long ago, and formed an article in the materia medica of by-gone days; and, lastly, it is in this group that the mythical and the real meet in the consideration of the giant cuttle-fishes which the myth and fiction of the past postulated, and which modern zoölogy numbers among its realities.

The past history of the cuttle-fishes unites in itself a knowledge at once of their present position in the animal world and of their prog-

ress toward that position. The history of their past begins with the recognition of the pearly nautilus (Fig. 3) as a being which, as a four-gilled cuttle-fish possessing an external many-chambered shell, stands alone in the world of life. It is the tribes of two-gilled cuttle-fishes which people our ocean to-day, and which exhibit all the gradations of form and size, from the minute *Spirula* (Fig. 6) to the great *Architeuthis* of the American coasts. The history of the cuttle-fishes in time begins in the far-back epoch represented by the Lower Silurian rocks of the geologist. There are entombed the first fossil cuttle-fishes, represented by their chambered shells. The genus *Orthoceras*, represented by shells of straight form, is thus among the oldest members of the cuttle-fish race. The *Nautilus* genus itself begins in the Upper Silurian rocks; we may trace the well-known shells upward to the Carboniferous strata, where they are best developed; and we follow the genus onward in time, as it decreases in numbers, until we arrive at the existing order of things, in which the solitary nautilus remains, as we have seen, to represent in itself the fullness of cephalopod life in the oceans of the past. The older or Palæozoic rocks reveal a literal wealth of these chambered shells, and therefore of the existence of the four-gilled cuttle-fishes as the founders of the race. When we ascend to the Mesozoic rocks (ranging from the Trias to the Chalk), we meet with new types of the chambered shells well-nigh unknown in the Palæozoic period. In the Mesozoic rocks appears the fullness of *Ammonite* life. Here we find shells named after the horns of the Egyptian god, Jupiter Ammon; these, instead of being tolerably plain, like the *Nautilidæ*, exhibit beautifully sculptured outlines, and folded septa, or partitions, between the chambers of the shell. The shells allied to *Nautilus* and occurring in the Palæozoic formations differ from Nautilus chiefly in their varying degrees of curvature or straightness. *Lituites* is a curved form allied to *Nautilus;* while *Orthoceras* and *Gomphoceras* are groups representing the straightened forms. But in the Silurian period more complex forms appear, with elaborate and folded septa. These are the early Ammonites, such as *Goniatites* and *Bactrites*. In the Secondary rocks we find the still more complex true Ammonites themselves. Here the *lobes* and *saddles* of the shells, as the edges of the septa are named, are of the most elaborate patterns, while the shapes of shell are of the most varied character (*Baculites, Turrilites, Ammonites*, etc., Fig. 5).

FIG. 6.—SPIRULA.

There is thus an advance and progression exhibited in the development of the four-gilled races which accords perfectly with the theory of evolution and descent. The seas of the Trias, Oolite, and Chalk periods must have literally swarmed with these striking forms of cephalopod life; but as the close of the Chalk period dawned, and as

the Secondary age came to an end, the fullness of the Ammonite generations disappeared for ever. In the succeeding Tertiary period not a single Ammonite of any kind occurs ; the genus *Nautilus* remaining in the Tertiary period—as it survived into the Mesozoic or middle period—as the sole representative of a once plentiful four-gilled population.

If the history of the four-gilled cuttle-fishes is thus plainly told as having its beginnings in the Palæozoic period, its maximum development in the Mesozoic period, and its lingering presence in the Tertiary period, the two-gilled cuttle-fishes may be said to possess an equally interesting history. Compared with their four-gilled neighbors, the two-gilled forms are late comers upon creation's scene. Not a single fossil two-gilled form occurs in all the Palæozoic period, extending from the Laurentian to the Permian rocks. If they existed in Palæozoic seas, they have at least left no trace of their presence. Their softness of body may perchance have contributed to their elimination from the oldest fossil records ; but, laying aside mere conjecture, we find the first fact of the past history of the two-gilled forms in the presence of the fossil shells of the extinct *Belemnites* in the Triassic rocks. The Belemnites themselves disappear at the close of the Mesozoic period ; but fossilized shells of species allied to our living Sepias occur in the Oolite ; and the internal shells of squids are found in the Lias or lower Oolites. In the Tertiary rocks, Argonaut (Fig. 4) shells occur in the Pliocene deposits ; the Eocene rocks also give us sepia remains ; and various other two-gilled fossils (*Beloptera*, etc.) are found in Eocene and Miocene formations.

Briefly summarized, then, we find that the chief details in the past history of the cuttle-fishes are told when we are reminded that the four-gilled forms are by far the more ancient of the two groups ; that they first appear in the Silurian rocks, while the two-gilled forms appear first in the Secondary rocks ; and, lastly, that the record of the one group is the converse of the other. For, the four-gilled species attained their maximum in the Primary and Secondary rocks, and have practically died out, leaving the pearly nautilus as their sole representative in existing seas. The two-gilled race, starting in the Secondary rocks, and leaving the extinct belemnites as a legacy to the past, have, on the other hand, flourished and progressed, and attain their maximum, both in size and numbers, in the existing seas and oceans of our globe.

What ideas concerning the origin and evolution of these animals may be legitimately deduced from the foregoing facts of their structure and distribution in time? In the answer to such a question, asked concerning any group of living beings, lies the culminating point of all biological science. That the cuttle-fishes fall nominally into their place in the scale of being indicated by evolution, and that in their individual development, in the growth of their special organs, such as

eye and ear, as well as in the general relations they bear to each other as living forms, they illustrate the results of progressive development, can not for a moment be doubted. The further fact that the existing four-gilled nautilus, despite its lengthy ancestry, as regards its brain, its eye, its tentacles, and other features of its history, is a less specialized and lower form than the two-gilled cuttle-fishes, clearly points to the evolution of the two-gilled from the four-gilled stock. The more active and structurally higher races of to-day, in other words, have sprung from the less specialized and lower cuttle-fishes of the geological yesterday. No question, then, of the reality of progressive development, as a factor in evolving new species and groups of cuttle-fishes from the confines of already formed species, can be entertained.

Turning more specifically to the shell in general, we may discover in the modifications of this single structure a clew to the entire evolution of the cuttle-fish race. The "shells" of the two-gilled cuttle-fishes exist for the most part as horny "pens" or as limy plates, secreted by the "shell-gland" of the mantle which forms the true shell of all mollusks. Starting with the shells which are certainly oldest in point of time, and therefore of development, we find, in the Nautili and their neighbors, structures which represent fullness of shell-growth. It appears a long hypothetical journey from the well-developed shell of the nautilus type to the limy plate or horny "pen" shell of the squid. But the halting-places on the way diminish the apparent length of the journey, as they lessen the seeming irregularity of the path. The simple rudimentary shells of our two-gilled cuttle-fishes are to be regarded as the degenerate remains of structures fully developed in their ancestors. To this idea, their succession in time bears faithful witness; and to its correctness the connecting links, accessible to us, plainly testify.

Thus the history of the cuttle-fish shell forms an important chapter in the biography of the race. The rudimental shells of the two-gilled cuttle-fishes, like the teeth which never cut the gum in unborn whales, have a reference not to their present life, but to a former state of things. Contemplating the "pen" or "cuttle-bone" of a modern squid or sepia, our thoughts become molded in mental continuity with the past. There risé to view before our mind's eye the ancient Nautili and their sculptured kith and kin the ammonites, crowding the seabeds of the far-back Mesozoic, and still more remote Palæozoic ages. Then, through the operation of the inevitable laws of organic progress and advance—making the ancient world then, as they constitute our world to-day, the theatre of continual change—we see the two-gilled stock arise in secondary times from the four-gilled race. First there is seen the modification of shell. Concurrently with the decrease of shell comes increase of head-development and elaboration of nerve-centers, tending to make the new two-gilled form what we know it to be to-day—the wary, watchful organism, living in the waters above,

and occupying a sphere of vital activity immeasurably superior to the dull existence passed by its four-gilled ancestors on the ocean-bed. The shell degenerates more and more as the cuttle-fish race rises on its own branch of the animal tree. Development in numbers succeeds individual advance. The cephalopod tribes of to-day dawn fuller and fuller as the Tertiary period progresses. Thus the fullness of cuttle-fish life to-day, exhibited in all its strange weirdness, is interwoven, like the lines of human history itself, with the warp and woof of the past. And not the least important clew to the history of that past is found in the apparently insignificant "shell" we have discussed; since in its mere degeneracy it leads us backward in an instructive glance to those early times when the chief branches on life's tree had not reached their full fruition, and to the days when the world itself was young.

MOZLEY ON EVOLUTION.

By HERBERT SPENCER.

IN the "Reminiscences, chiefly of Oriel College," by the Rev. Thomas Mozley, there occurs on page 146, vol. i, the following passage:

> I had indulged from my boyhood in a Darwinian dream of moral philosophy, derived in the first instance from one of my early instructors. This was Mr. George Spencer, [honorary] Secretary of the Derby Philosophical Association, founded by Dr. Darwin,* and father of Mr. Herbert Spencer. My dream had a certain family resemblance to the "System of Philosophy" bearing that writer's name. There was an important and saving difference between the two systems, between that which never saw the light, and perished before it was born, without even coming to wither like grass on the house-tops, and that other imposing system which occupies several yards of shelf in most public libraries. The latter makes the world of life, as we see, and take part in it, the present outcome of a continual outcoming from atoms, lichens, and vegetables, bound by the necessities of existence to mutual relations, up to or down to brutes, savages, ladies and gentlemen, inheriting various opinions, maxims, and superstitions. The brother and elder philosophy, for such it was, that is mine, saved itself from birth by its palpable inconsistency, for it retained a divine original and some other incongruous elements. In particular, instead of rating the patriarchal stage hardly above the brute, it assigned to that state of society a heavenly source, and described it as rather a model for English country gentlemen—that is, upon the whole, and with certain reservations.

As I find, by inquiring of those who have read it, this passage leaves the impression that the doctrines set forth in the "System of

* It was more than a dozen years after Dr. Darwin's death in 1802 when my father became honorary secretary. I believe my father (who was twelve years old when Dr. Darwin died) never saw him, and, so far as I know, knew nothing of his ideas.

Synthetic Philosophy," as well as those which Mr. Mozley entertained in his early days, were in some way derived from my father. Were this true, the implication would be that during the last five-and-twenty years I have been allowing myself to be credited with ideas which are not my own. And, since this is entirely untrue, I can not be expected to let it pass unnoticed. If I do, I tacitly countenance an error, and tacitly admit an act by no means creditable to me.

I should be the last to underestimate my indebtedness to my father, for whom I have great admiration, as will be seen when, hereafter, there comes to be published a sketch of him which I long ago prepared in rough draft. But this indebtedness was general and not special—an indebtedness for habits of thought encouraged rather than for ideas communicated. I distinctly trace to him an ingrained tendency to inquire for causes—causes, I mean, of the physical class. Though far from having himself abandoned supernaturalism, yet the bias toward naturalism was strong in him, and was, I doubt not, communicated (though rather by example than by precept) to others he taught as it was to me. But while admitting, and indeed asserting, that the tendency toward naturalistic interpretation of things was fostered in me by him, as probably also in Mr. Mozley, yet I am not aware that any of those *results* of naturalistic interpretation distinctive of my works are traceable to him.

Were the general reader in the habit of criticising each statement he meets, he might be expected to discover in the paragraph quoted above from Mr. Mozley reasons for skepticism. When, for example, he found my books described as occupying several yards of library-shelves, while in fact they occupy less than two feet, he might be led to suspect that other statements, made with like regard for effectiveness rather than accuracy, are misleading. A reperusal of the last part of the paragraph might confirm his suspicion. Observing that, along with the allegation of "family resemblance," the closing sentence admits that the course of human affairs as conceived by Mr. Mozley was the reverse in direction to the course alleged by me—observing that in this only respect in which Mr. Mozley specifies his view it is so fundamentally anti-evolutionary as to be irreconcilable with the evolutionary view—he might have further doubts raised. But the general reader, not pausing to consider, mostly accepts without hesitation what a writer tells him.

Even scientific readers, even readers familiar with the contents of my books, can not, I fear, be trusted so to test Mr. Mozley's statement as to recognize its necessary erroneousness; though a little thought would show them this. They would have but to recall the cardinal ideas developed throughout the series of volumes I have published, to become conscious that these ideas are necessarily of much later origin than the period to which Mr. Mozley's account refers. Though, in Rumford's day and before, an advance had been made toward the doc-

trine of the correlation of heat and motion, this doctrine had not become current; and no conception, even, had arisen of the more general doctrine of the correlation and equivalence of the physical forces at large. Still more recent was the rise and establishment of the associated abstract doctrine commonly known as the "conservation of energy." Further, Von Baer's discovery, that the changes undergone during development of each organic body are always from the general to the special, was not enunciated till some eight years after the time at which Mr. Mozley was a pupil of my father, and was not heard of in England until twenty years after. Now, since these three doctrines are indispensable elements of the general theory of evolution (the last of them being that which set up in me the course of thought leading to it), it is manifest that not even a rude conception of such a theory could have been framed at the date referred to in Mr. Mozley's account. Even apart from this, one who compared my successive writings would find clear proof that their cardinal ideas could have had no such origin as Mr. Mozley's account seems to imply. In the earliest of them—"Letters on the Proper Sphere of Government"—published in 1842 and republished as a pamphlet in 1844, the only point of community with the general doctrine of evolution is a belief in the modifiability of human nature through adaptation to conditions (which I held as a corollary from the theory of Lamarck) and a consequent belief in human progression. In the second and more important one, "Social Statics," published in 1850, the same general ideas are to be seen, worked out more elaborately in their ethical and political consequences. Only in an essay published in 1852 would the inquirer note for the first time a passing reference to the increase of heterogeneity as a trait of development, and a first recognition of this trait as seen in other orders of phenomena than those displayed by individual organisms. Onward through essays published in several following years, he would observe further extensions in the alleged range of this law; until, in 1855, in the "Principles of Psychology," it begins to take an important position, joined with the additional law of integration, afterward to be similarly extended. Not until 1857, in two essays then published, would he find a statement, relatively crude in form, of the law of evolution, set forth as holding throughout all orders of phenomena, and joined with it the statement of certain universal physical principles which necessitate its universality. And only in 1861 would he come to an expression of the law approximating in definiteness to that final one reached in 1867. All which facts the scientific reader who took the trouble to investigate would see are conclusive against the implication contained in Mr. Mozley's statement; since, were this implication true, my early writings would have contained traces of the specific doctrine set forth in the later ones. But, as I have said, even a reader of my books can not be trusted to recall and consider these facts, but will certainly, in many

cases, and probably in most, passively accept the belief Mr. Mozley suggests.

Seeing this, I have felt it requisite definitely to raise the issue; and for this purpose have written to Mr. Mozley the following letter. It is made long by including a general outline of the doctrine of evolution, which it was needful to place before him that he might be in a position to answer my question definitely. Perhaps I may be excused for reproducing the letter in full, since ninety-nine out of a hundred do not know what the doctrine of evolution in its wider sense is, but suppose it to be simply another name for the doctrine of the origin of species by natural selection:

"MY DEAR SIR: The passages from three letters of my father, sent herewith—one written in 1820, which was about the date referred to in your account of him, one written some thirteen years later, and the other twenty years later—will prove to you how erroneous is the statement you have made with regard to his religious beliefs. Having in this case clear proof of error, you will, I think, be the better prepared to recognize the probability of error in the statements which you make concerning his philosophical ideas and the ideas which, under his influence, you in early life elaborated for yourself.

"The passage in which you refer to these gives the impression that they were akin to those views which are developed in the 'System of Synthetic Philosophy.' I am anxious to ascertain in what the alleged kinship consists. Some twelve years ago an American friend requested me, with a view to a certain use which he named, to furnish him with a succinct statement of the cardinal principles developed in the successive works I have published. The rough draft of this statement I have preserved; and, that you may be enabled definitely to compare the propositions of that which you have called 'the younger philosophy' with that which you have called 'the elder,' I copy it out. It runs as follows:

"'1. Throughout the universe in general and in detail there is an unceasing redistribution of matter and motion.

"'2. This redistribution constitutes evolution where there is a predominant integration of matter and dissipation of motion, and constitutes dissolution where there is a predominant absorption of motion and disintegration of matter.

"'3. Evolution is simple when the process of integration, or the formation of a coherent aggregate, proceeds uncomplicated by other processes.

"'4. Evolution is compound when, along with this primary change from an incoherent to a coherent state, there go on secondary changes due to differences in the circumstances of the different parts of the aggregate.

"'5. These secondary changes constitute a transformation of the homogeneous into the heterogeneous—a transformation which, like the first, is exhibited in the universe as a whole and in all (or nearly all) its details; in the aggregate of stars and nebulæ; in the planetary system; in the earth as an inorganic mass; in each organism, vegetal or animal (Von Baer's law otherwise ex-

pressed); in the aggregate of organisms throughout geologic time; in the mind; in society; in all products of social activity.

"'6. The process of integration, acting locally as well as generally, combines with the process of differentiation to render this change not simply from homogeneity to heterogeneity, but from an indefinite homogeneity to a definite heterogeneity; and this trait of increasing definiteness, which accompanies the trait of increasing heterogeneity, is, like it, exhibited in the totality of things and in all its divisions and subdivisions down to the minutest.

"'7. Along with this redistribution of the matter composing any evolving aggregate there goes on a redistribution of the retained motion of its components in relation to one another; this also becomes, step by step, more definitely heterogeneous.

"'8. In the absence of a homogeneity that is infinite and absolute, that redistribution, of which evolution is one phase, is inevitable. The causes which necessitate it are these:

"'9. The instability of the homogeneous, which is consequent upon the different exposures of the different parts of any limited aggregate to incident forces. The transformations hence resulting are complicated by—

"'10. The multiplication of effects. Every mass and part of a mass on which a force falls subdivides and differentiates that force, which thereupon proceeds to work a variety of changes; and each of these becomes the parent of similarly-multiplying changes; the multiplication of them becoming greater in proportion as the aggregate becomes more heterogeneous. And these two causes of increasing differentiations are furthered by—

"'11. Segregation, which is a process tending ever to separate unlike units and to bring together like units—so serving continually to sharpen, or make definite, differentiations otherwise caused.

"'12. Equilibration is the final result of these transformations which an evolving aggregate undergoes. The changes go on until there is reached an equilibrium between the forces which all parts of the aggregate are exposed to, and the forces these parts oppose to them. Equilibration may pass through a transition stage of balanced motions (as in a planetary system), or of balanced functions (as in a living body), on the way to ultimate equilibrium; but the state of rest in inorganic bodies, or death in organic bodies, is the necessary limit of the changes constituting evolution.

"'13. Dissolution is the counter-change which sooner or later every evolved aggregate undergoes. Remaining exposed to surrounding forces that are unequilibrated, each aggregate is ever liable to be dissipated by the increase, gradual or sudden, of its contained motion; and its dissipation, quickly undergone by bodies lately animate and slowly undergone by inanimate masses, remains to be undergone at an indefinitely remote period by each planetary and stellar mass, which since an indefinitely distant period in the past has been slowly evolving; the cycle of its transformations being thus completed.

"'14. This rhythm of evolution and dissolution, completing itself during short periods in small aggregates, and in the vast aggregates distributed through space completing itself in periods which are immeasurable by human thought, is, so far as we can see, universal and eternal—each alternating phase of the process predominating now in this region of space and now in that, as local conditions determine.

"'15. All these phenomena, from their great features down to their minutest details, are necessary results of the persistence of force, under its forms of mat-

ter and motion. Given these as distributed through space, and their quantities being unchangeable, either by increase or decrease, there inevitably result the continuous redistributions distinguishable as evolution and dissolution, as well as all those special traits above enumerated.

"'16. That which persists unchanging in quantity but ever changing in form, under these sensible appearances which the universe presents to us, transcends human knowledge and conception—is an unknown and unknowable power, which we are obliged to recognize as without limit in space and without beginning or end in time.'

"I am not aware that my father entertained any of these views, either definitely or vaguely. But if he did, or if under his influence you reached views similar to these or any of them, it will, I presume, be possible to indicate the resemblances. Or, if specific resemblances are not alleged, still it will be possible to point out what were the ideas you received from him which potentially involved conclusions such as are above set forth.

"I fear I am entailing some trouble upon you in asking an answer to this question, but the importance of the matter must be my apology.

"I am, my dear sir, faithfully yours,

"HERBERT SPENCER."

In Mr. Mozley's reply he stated that he had been obliged already to send off his corrections for a second edition, adding that, "as, therefore, nothing can be done now, you would not care for any discussion." The result is, that I remain without any reply to my question. One passage, however, in Mr. Mozley's letter serves to give a widely different meaning to his statement; and, having obtained his permission, I here quote it as follows: "You will observe that I have only a vague idea of my own 'philosophy,' and I can not pretend to an accurate knowledge of yours. I spoke of a 'family likeness.' But what is that? There is a family likeness between Cardinal Newman's view and his brother Frank's."

Now, if the "family likeness" alleged is not greater than that between the belief of a Roman Catholic and the belief of a Rationalist who retains his theism, my chief objection is removed; for just as the views of the brothers Newman have a certain kinship in virtue of the religious sentiment common to them, so Mr. Mozley's early views and my own may have had the common trait of naturalistic interpretation—partially carried out in the one and completely in the other: a common trait, however, which would give Mr. Mozley's early views a "family likeness" to other philosophies than mine. This being understood, the only further objection to Mr. Mozley's statement which I have to make is that I do not see how, even in this vague sense, a likeness can be alleged between that which he names and describes as "a *moral* philosophy" and "a system of philosophy" of which the greater part is concerned with the phenomena of evolution at large—inorganic, organic, and super-organic—as interpreted on physical prin-

ciples, and of which only the closing portion sets forth ethical conclusions as corollaries from all the conclusions that have preceded.

There remains only to answer the question, How could Mr. Mozley have been led to imagine a resemblance between things so different? He has himself gone far toward furnishing an explanation. In his introduction (page 1) he admits, or rather asserts, that "reminiscences are very suspicious matter"; and that "the mental picture of events long passed by, and seen through an increasing breadth of many-tinted haze, is liable to be warped and colored by more recent remembrances, and by impressions received from other quarters." He adds sundry illustrations of the extreme untrustworthiness of memory concerning the remote past; and in chapter lxxxiii he characterizes Denison's "Reminiscences of Oriole College" as a "jumble of inaccuracies, absurdities, and apparent forgets." Moreover, he indicates (page 4) a special cause of distortion, saying of those "whose memory is subordinate to imagination and passion" that "they remember too easily, too quickly, and too much as they please." Now, as is implied by his religious ideas and ecclesiastical leanings, and as is also shown by a passage in which he refers to the scientific school with manifest aversion, Mr. Mozley is biased toward an interpretation which tends to discredit this school, or a part of it; and, obviously, to fancy a resemblance between scientific views now current and those which he describes as a "dream" of his youth, which disappeared with his manhood, is not unsatisfactory. On looking through the "many-tinted haze" of sixty years at what he admits to be "a vague idea" of his early philosophy, he has unconsciously "warped and colored" it, and imagined in it a resemblance which, as I have shown, it could not possibly have had.

I will add only that serious injustice is apt to be done by publication of reminiscences which concern others than the writer of them. Widely diffused as is Mr. Mozley's interesting work, his statement will be read and accepted by thousands who will never see this rectification.—*Athenæum.*

EXPLOSIONS AND EXPLOSIVES.

By ALLAN D. BROWN,
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THE chief explosive mixture used in the arts of war and peace will probably for a long time continue to be that which we know by the name of gunpowder. It has been used so long that its origin (like that of the mariner's compass) is entirely lost in the misty atmosphere of the middle ages, if indeed it was not known before the Christian era. The ingredients spoken of by Roger Bacon in 1237, in his for-

mula for "making thunder and lightning," are still in use, and in nearly the same proportion now as at that early date. The three solid substances which, when properly and intimately mixed, form gunpowder, are saltpeter, sulphur, and charcoal; the first being three fourths, or a little more, of the mixture, the two latter, in nearly equal but varying proportions, forming the remaining one fourth. The saltpeter contains a large amount of oxygen, which it gives up with considerable readiness upon the application of heat; this unites with the carbon contained in the charcoal, forming a large volume of carbonic-acid gas; the potash of the saltpeter unites with the sulphur, while the nitrogen is set free, adding to the volume of the gases evolved. As these gases are given off with great rapidity, they are still further expanded by the action of the heat produced by the change of the solids into the gaseous form, until, under ordinary circumstances, they occupy a volume nearly three hundred times as great as that occupied by the powder itself. One can easily imagine that the expansion of a pound of powder to a size (if we may so say) so much greater than its original bulk would exert a tremendous pressure upon any object in which it was confined. If a small quantity of powder is freely exposed in the air and fired, the resulting explosive effect is small, as the gases produced so rapidly can readily push aside the air; but if it be confined in a large block of steel, in which is a cavity which will just receive it snugly, the resulting pressure is nearly ninety-three thousand pounds to the square inch.

From this illustration it will at once be understood that confinement, in a greater or less degree, is necessary, in order that the greatest amount of work may be accomplished by the explosion. Those explosives which give off their gases with intense rapidity require but little restraint, while the slower ones require more confinement. Among these less quick ones must be reckoned gunpowder, for, although the explosion seems to follow immediately upon the application of heat, yet an appreciable amount of time really elapses, in which the combustion goes on.

The ingredients of which gunpowder is composed are selected with the greatest possible care: the saltpeter is procured chiefly from India, being extracted from the soil by natural processes and then secured by the natives, for marketing. It is also largely prepared by artificial means, it being quite evident that it would not do for any country to depend upon a supply without its own borders in case of war. In this process, heaps of earth are mixed with decomposing organic matter—ashes, old mortar, and materials of like nature—the whole being wet with the liquor from stables sufficiently to keep it in a moist condition; the moistened heaps are worked over from time to time, and the air allowed free access. A chemical reaction takes place, and in time the crude saltpeter appears upon the exterior of the heap, whence it is removed and treated for the extraction of the pure

material. Both the India and the artificial products are mixed with hot water, which takes up the salts, leaving the earthy matters behind; this liquid is then evaporated, the saltpeter crystallizing as a fine white powder; if the original be very crude, this product is again subjected to a similar process.

The charcoal requires more care in its preparation than either of the other ingredients, as upon its quality depends largely the violence of the action of the powder; the more nearly pure carbon it is, the better will be the result. It is made from some very light wood, such as the black alder or willow, as these contain much carbon, and but little ash: small pieces of these woods, stripped of their bark, are placed in a retort which is kept at a uniform heat; the vapors are allowed a free exit, and the roasting is kept up until the experienced eye of the workman warns him that it is time to withdraw the charge, lest it be overburned. The entire contents of the retort are removed at once, and covered in air-tight drums, where the charcoal is left to cool. Thus prepared, charcoal is quite a different material from that in ordinary use; it being of a bluish-black tinge, somewhat elastic and slightly resonant when struck lightly with the finger, with the appearance of the woody fiber clear and distinct.

The sulphur is prepared from its ore, by roasting the latter in a retort, the vapors given off being condensed, and the resulting liquid run into molds, and allowed to harden.

Having procured the materials of proper fineness and in the desired proportions, the sulphur and charcoal are placed in a revolving cylinder with cylindrical rollers inside, by the action of which they are broken up into small pieces. These are then transferred to a similar cylinder containing bronze or zinc balls, in which they become very highly pulverized. When this is fully accomplished, the saltpeter is mixed with them, and the whole mass placed in the incorporating mill, being kept moist enough to be like dough, but still not too wet, as that would interfere with its proper mixture. This mill consists of two heavy iron wheels, revolving at the extremities of an horizontal axis, the whole being revolved about a vertical axis in the center of a cast-iron bed, surrounded with wooden sides. As this upright axis revolves, the wheels move about their own axes, having at the same time a forward motion, which causes the powder to be both mixed and pressed at the same time; in this manner, the mixture is rendered much more intimate than by the old method of stamping, in which the ingredients were placed in huge wooden mortars, and subjected to the action of heavy pestles of the same material. When sufficiently mixed, the mill-cake, as it is then called, is allowed to dry; after which it is taken to the breaking-down machine, where, on passing between heavy wooden rollers, it is broken into small fragments. The next step is to subject it to the action of the press; this is an horizontal wooden trough in which are placed (about an inch and a

half apart) accurately fitting sheets of hard rubber; the crushed powder is shoveled into the trough, and a powerful hydraulic press applied; a screw-press would be dangerous, as particles of powder might get into the thread of the screw, and be fired by the friction. When removed from the press, the powder is in slabs of close texture, not unlike slate in appearance. These slabs go next to the granulator, in which they pass through a series of rollers, separated by sieves; as the broken powder passes from one set of rollers to the succeeding one, the sieves are kept in constant agitation, the pieces which pass through them falling to the bottom of the machine, where they are collected. Each sort is then taken to a rotating reel of wire gauze, in which, as it revolves, the dust is removed. If the powder is to be glazed, the clean grains are placed in a slowly revolving drum, with a very small quantity of plumbago, or black-lead; if glazing is not required, as is the case with some sorts of powders, the same process is gone through, the black-lead being omitted; in this manner, the grains are rounded off, and rendered smooth.

The final step is the drying, which is done in a steam-heated house, the powder being spread upon shelves for this purpose. The finished product is placed in oak kegs fastened with copper hoops, and care is always enjoined to use no iron tool in opening them. These various operations are conducted in buildings situated at a distance from each other sufficiently great to prevent the explosion of one causing that of another; they are generally placed along the banks of some stream from which the requisite power for operating the machinery can readily be obtained.

The manner in which the powder burns is greatly affected by variations in its manufacture: the greater the size of the grains, the more slowly does the burning take place, as the combustion goes on upon the surface, particle by particle; the shape of the grain regulates the amount of space taken up by the charge, as also in some degree the amount of surface exposed to the action of the flame; the density (depending upon the amount of pressure applied to the press-cake) also affects the rapidity of the burning; the lower the density, the more quickly does the combustion take place.

A desire to reduce the strain upon the walls of the modern guns has led to many experimental trials of various sizes and shapes of grain; the principal credit for these ideas is unquestionably due to an American ordnance-officer, Rodman. Much care has been taken in this regard, and we now see much higher velocities given to projectiles than heretofore, with, at the same time, less strain upon the gun.

There are various other mixtures which are explosive in their character, but their use is prevented by various considerations, chiefly by the fact of their greater sensitiveness to friction or percussion, and their consequent greater danger, or by their corroding effect upon the metal of which the gun is constructed. A powder which might prove

to be useful where a stronger explosive than ordinary gunpowder is desired is known as Abel's picric powder; this is a mixture of picrate of ammonia and saltpeter, prepared in an ordinary powder-mill by the processes just detailed. Picric acid (by means of which the picrate of ammonia is obtained) is derived from the action of strong nitric acid upon carbolic acid. This powder requires confinement to develop its force, is not exploded by friction, and, as it absorbs no moisture by exposure to the air, can be used and stored like gunpowder; for the ordinary uses of gunnery, however, it can never supersede its elder brother.

As has already been said, gunpowder burns, rapidly it is true, but nevertheless the action is a true combustion. We now come to the consideration of a new class of explosives, which do not burn, but resolve themselves into their constituent gases immediately upon the application of the force which suffices to bring about their disintegration. These are not mixtures like gunpowder, but definite chemical compounds in which the carbon, oxygen, and hydrogen are held a little way apart, as it were, by the nitrogen, but ready to rush together at the first opportunity; the explosion of one particle means generally the contemporaneous explosion, or detonation, of the whole mass: with such bodies confinement to any great extent is not necessary.

Pre-eminent among these detonating substances for its use in mining and engineering operations of a like character stands the compound known as nitro-glycerine. This is manufactured in greatly increasing quantities in many places, both in this country and in Europe, and its use for the purposes above mentioned is becoming more and more general. Its transportation in the liquid state being excessively dangerous, it was for a long time but little used; but, it having been ascertained that it can be mixed with other materials and carried with comparative safety, its field of usefulness has become greatly enlarged. It is formed by the action of very strong nitric acid upon glycerine at a low temperature, the resulting product being removed and washed free of its impurities.

Glycerine is a by-product of the stearine-candle manufacture, being separated from the stearic acid contained in animal fat upon the application of superheated steam. It is subsequently redistilled until its impurities are removed, in which condition it is proper to be used in the manufacture of nitro-glycerine. Unfortunately, however, many manufacturers do not restrain themselves to a pure quality of the glycerine, but, using inferior ones (which are, of course, cheaper), make a nitro-glycerine which is of a much more dangerous character than should ever be used.

The process of manufacture is as follows: The nitric acid is mixed with twice the quantity of sulphuric acid, and both then mixed with the glycerine; the nitric acid acts upon the glycerine, leaving a quantity of water free; were the sulphuric acid not present, this water

would dilute the nitric acid, but, as the sulphuric acid has a greater affinity for water, it takes it up, leaving the other of its normal strength. To proceed to the details: Around a brick chimney is placed a wooden trough, containing large earthenware pitchers in which is the acid mixture, the trough being filled with ice. On a shelf above this trough are placed bottles holding glycerine, communicating each with a pitcher below, by means of a small rubber tube, so arranged as to permit the passage of the liquid in a fine stream. The contents of the pitchers are kept in a constant state of agitation by a stream of cold dry air forced through them; as the reaction between the nitric acid and the glycerine goes on, great heat is evolved, accompanied by nitrous fumes extremely unpleasant and unhealthy to inhale; these fumes are drawn into the chimney through an overhanging hood, by means of the draught created by a furnace-fire at the bottom. Great care is necessary that the temperature be not allowed to rise above 48° Fahr., as there would then be danger of the newly formed nitro-glycerine taking fire and exploding; constant attention must be paid to this point, each pitcher being tried with a thermometer at short intervals. The proportion of materials is about two pounds of glycerine to twenty pounds of the acid, and at the expiration of the process the glycerine and nearly all the nitric acid have disappeared, forming nearly four pounds of their compound; the sulphuric acid, diluted as before mentioned, also remains. The nitro-glycerine is now partly in solution and partly suspended in the acid mixture; the contents of the pitchers are poured through a strainer into a vat of water, which is kept in agitation by a stream of compressed air: after all the pitchers are emptied, the air is shut off and the mixture comes to rest, when the nitro-glycerine settles at the bottom of the vat, and the acid water is then drawn off. It is next taken in small quantities at a time, and carefully washed a number of times, until all the acid is washed out, and only the pure nitro-glycerine remains; in this state it is thin, oily, creamy white, and opaque, but, on being placed in jars and allowed to stand, it soon becomes transparent. It is now ready for use as an explosive agent; it has a sweet, aromatic, pungent taste, and possesses the very peculiar property of causing an extremely violent headache when placed in a small quantity upon the tongue, or any other portion of the skin, particularly upon the wrist. It has long been employed by homœopathic practitioners as a remedy in certain kinds of headaches. In those who work much with it, the tendency to headache is generally overcome, though not always. It freezes at about 40° Fahr., becoming a white, half-crystallized mass, which must be melted by the application of water at a temperature of about 100° Fahr. If perfectly pure—that is, if the washing has been so complete as to remove all traces of the acid—it can be kept for an indefinite period of time; and, while many cases of spontaneous decomposition have occurred in impure specimens, there has never been known such an instance,

where the proper care has been given to all the details of the manufacture.

There are other methods of manufacture, differing, however, only in the details, the principle of course being the same.

When pure, nitro-glycerine is not very sensitive to friction, or even to moderate percussion : if a small quantity be placed on an anvil and struck with a hammer, that portion which is touched explodes sharply, but so quickly as to drive away the other particles ; if, however, it were even slightly confined, so that none could escape, it would all explode or detonate. It must be fired by a fuse containing fulminate of mercury (the compound used in percussion-caps), not being either readily or certainly fired by gunpowder, the shock of the latter not being sufficiently quick or sharp to detonate the nitro-glycerine. It is highly probable that in this case, as in that of other high explosives, the vibrations set up by the fulminate (which is not stronger than gunpowder) are of just such a character as to find an answering chord, so to speak, in the explosive, so that the desired effect is produced. This would seem to be a correct theory, for it is not always the most powerful explosive which most readily causes the explosion of another body. For instance, although nitro-glycerine is much more powerful than fulminate of mercury, yet seventy grains of it will not explode gun-cotton, while fifteen grains of the weaker fulminate will readily do so. The fuse generally used, then, for firing nitro-glycerine, is composed of from fifteen to twenty-five grains of fulminate, and this quantity is sufficient to detonate a large mass as well as a small one.

If flame be applied to nitro-glycerine it will not explode, but burn with comparative sluggishness. When frozen it is very difficult and uncertain of firing. If the material be perfectly pure, it forms, upon detonation, a volume of gases nearly thirteen hundred times as great as that of the original liquid ; these gases are also further expanded, by the heat developed, to a theoretical (though not practical) volume ten thousand times as great as that of the charge. Practically speaking, the forces exerted by gunpowder and nitro-glycerine are in the proportion of one to eight.

The great objection to nitro-glycerine, in its liquid state, is the difficulty of its transportation ; it is liable to leak from the packages in which it is contained, and there have been several occasions on which disastrous accidents have taken place owing to this circumstance. The explosion of a large case on board of a steamer in Aspinwall some twelve or fourteen years ago, and, about the same time, of a box in an express-office in New York, caused great precautions to be taken with regard to it, and also very great fear of it on the part of all transportation companies. Fortunately, it has been found that it can be carried from place to place by mixing it with some absorbent substance, which takes up a large quantity of it ; it is just as powerful in this state, the presence of the absorbent having no deleterious effect. This

mixture is called dynamite, or giant-powder; it is made by mixing nitro-glycerine with a siliceous earth, in the proportion of three to one by weight. This earth is a fine white powder, composed of the skeletons of microscopic animals; it is found in Hanover and also in New Hampshire—that coming from the latter locality being the finer, and therefore most used in this country. The dynamite formed by this mixture is not unlike moist brown sugar in appearance; care must be taken not to put too much nitro-glycerine in it, as there must not be such a quantity as would cause exudation. Its properties as an explosive, are, of course, those of the nitro-glycerine alone; but it can be much more readily handled, and there is less danger from either percussion or friction. It has been dropped from a height upon rocks, heavy weights have been allowed to fall upon it, and other experiments of a like nature have been made to show how readily it can bear transportation and hard knocks. This safety, however, presupposes a pure nitro-glycerine; and whenever an accident occurs it may safely be laid to the impurity of the explosive, and not to anything necessarily consequent upon the use of dynamite. Under the action of cold, dynamite freezes at 40° Fahr. in a hard, compact mass, in which condition it is very difficult to explode. Sometimes, however, it freezes in a loose and powdery state, and there is then no difficulty in causing its explosion with the ordinary fulminate-fuse. Generally speaking, however, it is best with this, as with nitro-glycerine, to thaw it out before attempting to use it. Instances have been known of careless men attempting to do this with a red-hot poker, with consequences, naturally, of a disastrous character. It will admit of being slightly moistened without injury, and hence can be used when gunpowder could not be. As a military explosive for mines and torpedoes, as also for the breaking up and destruction of guns, it has proved itself useful; and it has been used as a bursting-charge for shells, though this is considered dangerous.

Besides dynamite, there are several other mixtures of nitro-glycerine, in which the inactive siliceous earth is replaced by some active substance, such as charcoal, saw-dust, wood-fiber treated with acid, chlorate of potash, or even gunpowder. It is extremely doubtful whether anything is added to the explosive effect of the nitro-glycerine by their presence, as its own explosion is so rapid as to gain nothing from the slower combustion of these substances. Experiments with the pressure-gauge tend to show the correctness of this theory. Of all these combinations, that called cellulose dynamite is the best; it is a combination of the wood-pulp, so much used for the manufacture of paper, treated with nitric acid and nitro-glycerine; it possesses the excellent quality of being able to absorb a considerable quantity of water without injury; for this reason it may prove itself a commercial rival to dynamite pure and simple.

Large quantities of dynamite are manufactured in this country for

use in mining and engineering operations; among others, the Hoosac Tunnel and the works at Hallett's Point in New York harbor undoubtedly owed much to the powers of nitro-glycerine in hastening their completion. The effect of a confined charge upon rock is to pulverize the portion near the blast-hole, the action being so sudden, quick, and intense; it is, therefore, found better not to tamp the hole, a saving both of time and labor, allowing the gases a greater surface upon which to act. Ordinarily the dynamite is contained in paraffined paper cartridges, and is fired with a fulminate-fuse.

Gun-cotton is formed by the action of nitric acid on cotton—a portion of the hydrogen being displaced in the cotton, just as it is in the glycerine by the active constitution of the nitric acid. The essential features of the process are the same as those of the manufacture of nitro-glycerine; that is to say, a mixture of strong nitric and sulphuric acids is made, the cotton exposed to its action, and the excess of acid removed from the cotton by careful washing; the sulphuric acid plays the same part, namely, that of taking up the water formed, and so keeping the nitric acid at its full strength. As in the former case, only perfect purity will insure safety; the presence of acid in the gun-cotton will ultimately cause decomposition and explosion. Many accidents have taken place since the introduction of gun-cotton to public notice some thirty-five years ago; but, as in the case of nitro-glycerine, all of them may be ascribed to imperfect washing, reference being had, of course, to instances of what may be called spontaneous combustion. With the improved methods of to-day, however, and the exercise of ordinary care, gun-cotton can be rendered perfectly stable and safe, far safer for transportation than nitro-glycerine in any of its forms; when wet it can not be readily exploded, and hence it is generally carried in that state, and either dried for use or else exploded by the use of a dry primer of the same material. It possesses, however, the disadvantage of rapidly absorbing moisture, and hence it is extremely difficult to keep primers dry unless they are prepared with great care. In a military point of view this is no great objection, but commercially speaking it is, for the expensive water-proof cases would perhaps make its use financially impracticable.

The details of the usual process of its manufacture are as follows: cotton-waste is picked and cleaned, then dried at a high temperature. After cooling, in quantities of about a pound, it is immersed in the strong acid mixture contained in a trough surrounded by cold water; after a short exposure it is removed, and the acid pressed from it as far as practicable. After another immersion of twenty-four hours, it is placed in a centrifugal strainer, by the rapid revolutions of which nearly all the acid is expelled; it is then washed in a large amount of water, and again placed in the strainer. When the acid-water no longer remains, the gun-cotton is placed in the pulper, an oblong tub

full of water, in which revolves a wheel having strips of steel upon its rim, similar strips projecting from the bottom of the tub. As the wheel revolves, the floating pieces are drawn between the steel strips and thus reduced to a fine pulp. This is again washed for a long time by mechanical means, after which it is taken to the press, where nearly all the water is expelled from it, the final pressure applied being about fifteen thousand pounds to the square inch. When taken from the press, it is in the shape of a disk or cylinder, of a close texture, easily broken when dry, and capable of being cut in a manner not unlike pasteboard. When a small quantity is ignited by a flame, it burns quite rapidly, but quietly, if dry; if wet, it is consumed very slowly. If a large quantity is ignited, there may be sufficient confinement of the inner portions by the outer shell to cause an explosion. If dry loose gun-cotton be ignited, it burns with extreme rapidity, like a flash, but without any violence; in fact, a wisp placed on a small pile of gunpowder and fired will not ordinarily cause its explosion. In order to have a complete explosion of the dry material, fulminate of mercury must be used, and this is accordingly employed in the primers made for the explosion of that which is wet. Two pounds of the dry, detonated by twenty-five grains of fulminate, will cause the detonation of five hundred pounds of the wet. In this wet state it must be carefully guarded from a low temperature, as the expansion of the water in freezing will tend to break up the disks.

Many experiments have been made with a view to its adoption in gunnery practice, but it is not at all likely that either it or any of the high explosives will ever displace gunpowder; their action is so violent and sudden that, before the projectile has time to take up its motion in the bore of the gun, the walls yield and the piece is burst. Its use for military purposes must therefore be confined to mines and torpedoes, as in the case of dynamite, or as a bursting-charge for shells, for which purpose experiments show that it is most admirably adapted. It is used in Europe for torpedo purposes, and is carried for that use by war-vessels of the English and other navies.

The explosive gun-cotton is not the only kind made; another sort (in which a less amount of the hydrogen of the cotton is displaced) is used for making collodion, largely employed by photographers. This variety, called collodion gun-cotton, combined with nitro-glycerine, forms a new explosive agent called gum-dynamite, or explosive gelatine. Singular to relate, the ordinary gun-cotton used for explosive purposes will not enter into this combination, and hence probably the late discovery of the fact that it requires the collodion variety to do so. This is finely shredded, generally by hand, and placed in small quantities at a time in the nitro-glycerine, which is kept at a temperature of 80° Fahr. by means of a water-bath, the whole being constantly stirred with a wooden spatula; the proportion of materials is seven per cent by weight of the gun-cotton to ninety-three per cent of the nitro-glycerine.

The latter dissolves the former, and the result is an elastic, gelatinous, semi-transparent mass, which is easily cut or torn apart, and shows no trace whatever of nitro-glycerine on handling. Its explosive properties are unaffected by contact with water, and in this respect it is the most useful of all the high explosives for military purposes. With the change in the physical condition of the two components comes also a change in the ease of explosion; these two bodies, each of itself highly explosive, form when united one which is quite the reverse. When unconfined, a primer of fifty grains of fulminate will cause the explosion of but a very small portion of a charge, the rest being torn in pieces; if, however, it be strongly confined, so that the blow of the fulminate exerts its whole force, which is propagated through the gelatine, it then explodes with a violence as great as that of nitro-glycerine, if not somewhat greater. This latter point has not been fully determined, but the probabilities are that the expansion of the constituents of the gelatine is more complete and is accompanied with more heat than is the case with nitro-glycerine alone. The gelatine freezes at 40° Fahr., and in this state is fired with no difficulty whatever, being in this respect much superior to dynamite. When subjected to a pressure of two hundred and fifty pounds to the square inch, no nitro-glycerine is separated; the union between the two constituents seems to be complete and definite. If subjected to the action of flame, it takes fire less readily than dynamite, but burns very much like it, with perhaps a greater strength of flame, as if urged by a bellows. When heated to 100° it softens, but does not become at all greasy, and there is no exudation of nitro-glycerine. Explosion by the application of heat takes place at about 420°; but it is found that by the addition of a small amount of camphor, say four per cent, it will bear an increased heat of 100° before explosion. Experiments made with the gelatine thus camphorated show that the camphor exercises no deleterious effect upon the strength of the material, while rendering it less like jelly, and more like that form of confection known as fig-paste. Six per cent of camphor may be added without harm, but any greater quantity materially diminishes the explosive effect. Portions of this gelatine, both pure and camphorated, have been subjected to a constant heat of 100° for more than six weeks, and no exudation of the dangerous nitro-glycerine has been observed. It will not explode under circumstances which ordinarily render certain the detonation of either nitro-glycerine or dynamite—that is to say, a quantity of the gelatine will resist the shock of the detonation of another quantity placed within a very few feet of it; if very near, it may take fire and burn, but detonation will not ensue unless the two masses are almost in actual contact, and even then it will not always occur. It further possesses the property of permitting the impact of a ball from a gun without exploding, while both dynamite and gun-cotton may be readily detonated by a blow of this kind. All

these tests tend to show that it possesses in a high degree the elements desired in the ideal high explosive for military purposes, if not for commercial use.

So much difficulty was encountered in the first attempts at the construction of a suitable primer for its explosion, that it seemed doubtful whether it would ever be a practicable material, as it was thought that nitro-glycerine must be used to accomplish the desired result. Subsequent experiments conducted in this country have shown, however, that a dry gun-cotton fuse with a fulminate cap containing twenty-five grains will fire the gelatine with ease and certainty, even when unconfined. The problem so long confronting the manufacturer of explosives would seem to be nearly solved: the requisites of great power in small compass, of permanency when subjected to tropical heat, of ease of firing when but slightly confined, of safety from the explosion of neighboring masses of the same or on being struck by a projectile, and of not being affected injuriously by water, all seem to be fulfilled by this agent in a manner more complete than by any other.

If it should be found that a long-continued exposure to heat tends to produce decomposition, as may prove to be the case, greater care in the preparation of the materials from which it is manufactured will probably overcome this difficulty, and it will then bid fair to supersede gun-cotton for very many purposes, if it does not altogether take its place.

Constant allusion has been made to the use of fulminate of mercury as an agent for the firing of other explosives. It is prepared by dissolving mercury in nitric acid, and then mixing this solution with alcohol, in a vessel placed in a hot-water bath. Dense white fumes soon arise from the agitated liquid, until finally, the disturbance having subsided, the bottom of the vessel is found covered with a gray powder, which is afterward thoroughly washed. This gray powder is the fulminate used in the caps and cartridges familiar to sportsmen, as well as in the primers for cannon and the fuses for the explosion of a quantity of gunpowder or other explosives. Being harmless when wet, it is usually kept and handled in that condition. Generally speaking, electricity is the agent by means of which the fulminate is ignited; the fuse for this purpose is ordinarily constructed as follows: A brass or copper cylinder, about half an inch in diameter, closed at one end, is partially filled with the desired quantity of the wet fulminate; when this has become thoroughly dry, a wooden plug closing the entrance is inserted; in this plug are two holes, through each of which passes an insulated copper wire with bared ends, which project a short distance above the surface of the plug and are connected by a very small wire composed of an alloy of platinum and silver; around this wire, or bridge, as it is called, is twisted a small wisp of dry gun-cotton, which, when the plug is in place, comes in contact with the ful-

minate. After the insertion of the plug, the whole fuse is dipped in some water-proof composition and thoroughly dried. In use, the wires are connected with other wires leading from a galvanic battery or an electrical machine; when the current is caused to pass through these wires it reaches the bridge, where meeting with greater resistance to its progress, it raises the platinum wire to a heat sufficient to ignite the gun-cotton wisp, which in turn ignites the fulminate. It will be seen that in all cases it is absolutely necessary to keep the ultimate explosive dry, as even those high explosives which are not themselves affected by water require the use of perfectly dry primers. The orders of Cromwell must still be obeyed—to "trust in God, and keep your powder [or primers] dry."

THE UTILITY OF DRUNKENNESS.

By W. MATTIEU WILLIAMS.

IN the early argumentative struggles between the advocates of total abstinence from alcohol and their opponents, the latter believed they settled the question by affirming that "these things are sent for our use," and therefore that it was flying in the face of Providence to refuse a social glass. This and many similar arguments have subsequently been overturned by the abstainers, who have unquestionably been victorious "all along the line," especially since Dr. B. W. Richardson has become their commander-in-chief.

In spite of this, I am about to charge their serried ranks, armed with an entirely new weapon forged by myself from material supplied by the late Dr. Darwin, my thesis being that the drunkenness which prevails at the present day is promoting civilization and the general forward progress of the human race.

Malthus demonstrated long ago that man, like other animals, has a tendency to multiply more rapidly than the means of supporting his increasing numbers can be multiplied; he and his followers regarded this tendency as the primary source of poverty and social degradation. Darwin, starting with the same general law, deduces the very opposite conclusion respecting its influence on each particular species, though his antagonism to Malthus does not prominently appear, seeing that his inferences were mainly applied to the lower animals. Darwin shows that the onward progress, the development, or what may be described as the collective prosperity of the species, is brought about by over-multiplication, followed by a necessary struggle for existence, in the course of which the inferior or unsuitable individuals are weeded out, and "the survival of the fittest" necessarily follows; these superior or more suitable specimens transmit more or less of their advan-

tages to their offspring, which, still multiplying excessively, are again and again similarly sifted and improved or developed in a boundless course of forward evolution.

In the earlier stages of human existence, the fittest for survival were those whose brutal or physical energies best enabled them to struggle with the physical difficulties of their surroundings, to subjugate the crudities of the primeval plains and forests to human requirements. The perpetual struggles of the different tribes gave the dominion of the earth to those best able to rule it; the strongest and most violent human animal was then the fittest, and he survived accordingly.

Then came another era of human effort gradually culminating in the present period. In this, mere muscular strength, brute physical power, and mere animal energy have become less and less demanded as we have, by the aid of physical science, imprisoned the physical forces of nature in our steam-boilers, batteries, etc., and have made them our slaves in lieu of human prisoners of war. The coarse muscular, raving, yelling, fighting human animal that formerly led the war-dance, the hunt, and the battle, is no longer the fittest for survival, but is, on the contrary, daily becoming more and more out of place. His prize-fights, his dog-fights, his cockpits, and bull-baiting are practically abolished, his fox-hunting and bird-shooting are only carried on at great expense by a wealthy residuum, and by damaging interference with civilized agriculture. The unfitness of the remaining representatives of the primeval savage is manifest, and their survival is purely prejudicial to the present interests and future progress of the race.

Such being the case, we now require some means of eliminating these coarser, more brutal, or purely animal specimens of humanity, in order that there may be more room for the survival and multiplication of the more intellectual, more refined, and altogether distinctively human specimens. It is desirable that this should be effected by some natural or spontaneous proceeding of self-extinction, performed by the animal specimens themselves. If this self-immolation can be a process that is enjoyable in their own estimation, all the objections to it that might otherwise be suggested by our feelings of humanity are removed.

Now, these conditions are exactly fulfilled by the alcoholic drinks of the present day when used for the purpose of obtaining intoxication. The old customs that rendered heavy drinking a social duty have passed away, their only remaining traces being the few exceptional cases of hereditary dipsomania still to be found here and there among men and women of delicate fiber and sensitive organization.

With these exceptions, the drunkards of our time are those whose constitutions are so coarse, so gross and brutal, that the excitement of alcoholic stimulation is to them a delicious sensual delirium, a wild

saturnalia of animal exaltation, which they enjoy so heartily that every new raving outbreak only whets their appetite for a repetition. While sober they actually arrange and prepare for a forthcoming holiday booze; work and save money for the avowed purpose of purchasing the drink and its consequent ecstasies, which constitute the chief delights of their existence. When a professional criminal has "served his time," and is about to be released from prison, his faithful friends club together to supply him with the consolation of an uninterrupted course of intoxication; the longer its duration the greater his happiness, and the deeper his obligations of gratitude to the contributing "pals."

We know that such indulgence has swept away the Red Indian savage from the American Continent, and prepared it for a higher civilization, as the mammoth and grizzly bear have made way for the sheep and oxen; and this beneficent agent, if allowed to do its natural work, will similarly remove the savage elements that still remain as impediments to the onward progress of the more crowded communities of the Old World. If those who love alcoholic drinks for the sake of the excitement they induce are only supplied with cheap and abundant happiness, our criminal and pauper population will be reduced to a minimum.

It is commonly supposed that, because nearly all criminals are drunkards, therefore drunkenness is the chief cause of crime. This is a confusion of cause with effect. Crime and drunkenness go together because they are concurrent effects of the same organization. Alcoholic stimulation merely removes prudence and brings out true character without restraint or disguise. The brute who beats his wife when drunk would do so when sober if he dared and could; but what we call the sober state is with him a condition of cowardly depression and feebleness due to the reaction of intoxication. If a number of quarrelsome men assemble and drink together, they finish with fighting. If a similar number of kindly disposed men drink together, they overflow with generosity, profuse friendliness, and finally become absurdly affectionate. The citizen who would have subscribed but one guinea to a charity before dinner will give his name for five after the "toast of the evening."

My general conclusion is that all human beings (excepting the few dipsomaniacs above-named), who are fit to survive as members of a civilized community, will spontaneously avoid intemperance, provided no artificial pressure of absurd drinking customs is applied to them, while those who are incapable of the general self-restraint demanded by advancing civilization, and can not share its moral and intellectual refinements, are provided by alcoholic beverages with the means of "happy dispatch," will be gradually sifted out by natural alcoholic selection, provided no legislative violence interferes with their desire for "a short life and a merry one."—*Gentleman's Magazine.*

DELUSIONS OF DOUBT.

By M. B. BILL.

I PROPOSE to describe an extremely curious form of mental alienation which does not often occur, except among subjects whose minds have received a certain degree of culture, and the victims of which are seldom consigned to the asylum. It is an affection the subjects of which nearly always belong to the category of free eccentrics. I refer to the singular perturbation of mind which has been described by the elder Falret as the doubting disease (*maladie du doute*); by the younger Falret as partial insanity, with dread of the touch (*crainte du contact*) of exterior objects; by Oscar Berger as *Grübelsucht*, or the mania for subtilties; and by Legrand du Saulle as the folly of doubt, with delirium of the touch (*folie du doute avec délire du toucher*).

Waiving for the present the consideration of the tactile element, we might, perhaps, designate this mental state, which is always accompanied by consciousness, by the name which has frequently been given it of "metaphysical delirium." The case is really one of a morbid condition that is variable in its manifestations and which deserves, according to the particular forms in which it exhibits itself, all the names that have been given it. One patient, for example, will doubt everything, even his own existence, and will not be able to fix himself to any formal conviction. Another will manifest, besides this psychological state, a real fear of the contact of exterior objects. Another will feel a constant inclination to split hairs into quarters, and to exhaust all the subtilties of the ancient scholastics upon the most frivolous and trite subjects. All of these conditions, apparently so different, are brought together by one characteristic trait of intellectual restlessness.

"The true basis of this mental disease," says M. J. Vallent, in his "De la Folie Morale," "is a general disposition of the intellect to return continually upon the same ideas or the same acts, to feel a continuous necessity for repeating the same words or performing the same actions, without ever satisfying itself, or being convinced even by evidence. I have described certain phenomena of this order under the name of intellectual impulsions. I give a curious example of them. A young collegian, who had previously been very regular in his habits, was present at a party where some of his friends were jesting about the fatal influence attributed to the number thirteen. Suddenly an absurd thought occurred to him that, if thirteen was an unlucky number, it would be deplorable if God were thirteen, space thirteen, infinity thirteen, and eternity thirteen; and, to forefend such a woe, he every instant formulated in his mind an ejaculatory prayer thus conceived:

'God thirteen!' or else, 'Infinity thirteen! eternity thirteen!' Yet he was perfectly accountable, for he wrote to me himself that it was absurd to figure God as thirteen for an instant, to prevent his ever being it. But, pursued by this incessantly returning obsession, he kept on repeating his mental prayer at every instant, and ended with not being able to continue his studies, or to devote himself to any serious occupation."

We come now to the history of a patient whose case I have especially in view, who presents to us an example of the delirium in its purest, most elevated, and most metaphysical form, and least complicated with any foreign element. He is a young man of about twenty-eight years, of an agreeable and intellectual appearance and a fine physical development. He is the fifth son of his father, who is still living, and has no other infirmity than a light trembling. No hereditary vice exists in his family, but the patient had convulsions in his infancy, the last of which occurred when he was eight years old; since then he has had no other sickness. The normal soundness of his development is proved by the fact that he is now the support of his family. He is employed in a bank, and his services are much appreciated there. He is very intelligent, but has never received any but a rudimentary education. He has never read Descartes nor the other philosophers, and, when he involuntarily touches upon the most abstruse questions, it may be said that he makes metaphysics without knowing it. He was working diligently and regularly at his desk in the bank, when, one morning in June, 1874, he observed a sudden and curious change occur in the appearance of objects, concerning the nature of which I can not give a clearer idea than by repeating his own description of his impressions:

"In the month of June, 1874," he writes, "I felt quite suddenly, without any pain or giddiness, a change in the aspect of my vision. Everything seemed to me strange and queer, although the same forms and colors were preserved. Under the mistaken thought that the disagreeable sensation would pass away as it had come, I gave myself no more trouble about it, till a polypus made its appearance in my left nostril. I then went to a doctor and had him remove the polypus, without telling him anything about the new state of my vision. I thought the polypus was the cause of the strange appearance things presented to me, and that, when it was taken away, I would be all right again. But nothing of the kind came to pass. No remarkable change occurred till December, 1880, more than five years afterward, when I felt myself diminishing, and finally to disappear. Nothing was left of me but an empty body. From that time my personality has wholly vanished, and, in spite of all that I can do to get back that self that has escaped, I can not. Everything around me has become more and more strange; and now, not only do I not know what I am, but I can not give any account of what is called existence, reality.

What is it that has happened? Does everything around me really exist? What am I? What are all these things that are made like me? Why am I? Who am I? I exist, but outside of real life, and in spite of myself. Nothing, however, has given me death. Why are all these things around me which all present the same aspect? These things should enjoy life. What are these things?

"Although in this cruel condition, I have to do as I did before, and, without knowing why, something that does not appear to reside in the body urges me to continue as formerly; and I can not realize that this is true, that I really act. Everything is mechanical with me, and done unconsciously.

"When I experience a physical sensation, the substance that produces it, which is without any significance to me, is a blank. I feel a pressure on my temples and a stress between my eyes at the top of my nose, with a twitching of the nose to the top of my forehead. My ears hear well, but appear stopped up. My left nostril is sometimes obstructed, then free, then closed. Besides this strange sensation I remark that when any one speaks to me I answer immediately, and the answer is a reasonable one.

"My work has so far been done properly and without any mistake; and yet, when I say to myself, as I am saying continually, 'I am doing this, I am doing that,' I can not bring myself to realize that it is true.

"I may describe my condition in brief by saying that my personality has wholly disappeared; it seems to me that I have been dead for two years, and that the thing that exists does not recall anything that has a relation with any former myself. The manner in which I see things does not give me any realization of what they are, or that they exist, whence the doubt, etc.

"In view of this painful mental condition I come to ask you now whether I am not about to become mad, or whether I can do anything to deliver myself from a disorder which has continued so long, and which has so far only been modified. Without being able to enjoy life in any way, for I do not comprehend it, I am obliged to suffer everything that others, who are in their normal state, suffer."

The dominant fact in the psychological condition of this man is the absolute loss of the sentiment of reality. He compares himself to an empty paper sack. There is nothing in him. Nothing is left of him but an envelope which preserves a kind of external appearance, but which is in fact perfectly empty. He calls himself "a thing." Other men are "things" like him, but he does not believe in their real existence. He does not believe in what he sees, and when he puts out his hand to touch any object he is convinced in advance that he will find nothing but a phantom that will vanish. Although he really touches the object, the tactual added to the visual impression is still not enough to overcome his incredulity. The world, in his eye, is nothing

but a gigantic hallucination. He continues, in the mean time, to exercise the different functions of life. He eats, but it is a shadow of food that enters a shadow of a stomach; his pulse is only a shadow of a pulse. He is perfectly conscious of the absurdity of his ideas but can not overcome them. Along with this profound intellectual trouble the physical functions have remained perfectly normal. He complains of nothing but a slight pressure on his temples, and about the root of his nose. Deeply sensible of his moral condition, he is afraid he is going mad, and comes of his own accord to ask for a place in an asylum for the insane.

Facts of this kind have been known for a long time. Examples of them may possibly be found in antiquity, but the first authentic observation of one is given by Esquirol. He tells of a young woman brought up in trade, who was tormented by a scrupulous fear of doing wrong to others. Whenever she drew up an account she was apprehensive of making a mistake to the prejudice of some other one. One day, coming out from her aunt's house which she visited frequently, she was distressed lest she might involuntarily carry off in her pockets something belonging to her relative. Then she began to take much time to verify her accounts and bills, for fear that she might commit some error and do wrong to purchasers. At a later stage she was afraid, when she handled money, that something valuable would remain in her fingers. It was of no use to tell her that she could not keep a piece of money without perceiving it, or that the contact of her fingers could not change the value of the money she touched. "That is true," she would reply; "my anxiety is absurd and ridiculous, but I can not help it." She had to withdraw from trade. Gradually her apprehensions grew till they domineered over her whole life. Yet she was reasonable, intelligent, and lively.

The subject has since been studied and examined in all its aspects by Parchappe, Trélat, Baillarger, the two Falrets, Delasiauve, Morel, and Marcé. M. Legrand du Saulle published a monograph on it, embodying the results of the labors of his predecessors, in 1875. My colleague, M. Ritti, has published an interesting study upon it in the "Gazette Hebdomadaire," and a very complete article in the "Dictionnaire Encyclopédique"; and Griesinger and Dr. Oscar Berger have published essays upon it in Germany.

Let us pass to the description of the doubting folly (*folie du doute*). The beginning of the malady is sometimes obscure, but it is rarely abrupt, as in the case we have noticed. Generally the patient, as in the observation of Esquirol, exhibits odd scruples; he attracts attention by his eccentricities, and becomes incapable of any kind of labor; he is afraid of compromising himself, reads and rereads what he has just written, and takes infinite precautions not to make a mistake. A doctor, afflicted with this folly, having carefully examined the patients who consult him, gave them prescriptions that he had compiled with

the greatest care; but no sooner had his patient left the office than he would run out to take the paper away, fearing that he had made a mistake, that he had prescribed a poisonous dose of some medicine, or had given some direction inconsistent with the symptoms.

The doubting folly assumes an infinite number of different forms. Without making an excessive use of subdivisions, we must establish a few categories.

We give the first place, in the order of dignity, to the metaphysicians. They are constantly preoccupied with the insoluble problems of philosophy. They are continually questioning about God, about the universe, about the creation of the world. They will ask themselves, Who created the Creator? They seek for the origin of language. They trouble themselves about the end of things, about the immortality of the soul; or, turning their attention to the physical universe, they endeavor to comprehend the phenomena of nature and the fluids that direct them. Our patient belongs to this category. The great object of his preoccupations is self, personality, the real existence of the objects of which he has a subjective perception. He reproduces without knowing it the ideas and often the expressions of the great philosophers who have cast the lead into these abysses. Next to the metaphysicians, we should place those whom I will call the realists. They are occupied with more or less trivial questions that do not permit any elevation of thought. A Russian prince, mentioned by Griesinger, wanted to know why men were not as large as houses; another patient, why the fire-place that warmed his room was fixed against the wall instead of being in the middle of the room; a third, why there was only one moon instead of two. Once started in this course, the patient attaches himself with a morbid tenacity to the most insignificant subjects, and they become for him the point of departure of an intellectual torture.

Next are the scrupulous, of whom Esquirol's patient offers a finished type. They are always reproaching themselves about everything, are tiresome with the precision of their speech, and are constantly afraid that they have not told the exact truth.

The timorous form a fourth class. They are people who, always afraid they will compromise themselves, are incessantly taking exaggerated precautions, and live in a perpetual disquiet. A woman, who was an artist and very intelligent, could never go into the street without a fear that some one would fall down from a window to her feet. She would ask what the consequences of such an accident would be, and saw herself already arrested and taken to prison under an accusation of homicide.

A fifth class, whose mania is really insupportable, are the counters. They are persons who, wherever they may be, are concerned with the number of objects. In the doctor's office, instead of being occupied with the subject of consultation, they are counting the buttons on the

doctor's coat, or the books on his table. M. Legrand du Saulle tells of a patient who would say, "Excuse me, it is involuntary, but I must count." Some celebrated men seem to have a similar mania. Dr. Johnson never omitted to step on every stone of the walk as he passed them; and, if by any chance he thought he had forgotten one, he would go back to touch it. Napoleon was in the habit of counting by pairs the windows as he went along the street. Other forms of this madness escape all classification. I have just seen a patient in whom an acute rheumatism has been followed by a special trouble of the will. If he is going into a house, or out of it, he experiences an invincible resistance at the door-sill, and he has to be urged before he can get over the obstacle. Sometimes, on the public road, he can not pass a tree or a stone. He is also persecuted by certain words, and when one of them gets into his head he repeats it through the whole day.

Some of these patients are described as being affected with an exaggerated fear of the contact of exterior objects. This is true. It has been attested by numerous observers, but the doubting folly can exist without such a complication, and our patient, who has no fear of the kind, is a proof of it. On the other side, the fear of contact may exist without the doubting folly.

A few additional characteristics will complete our view. The doubting folly is a conscious insanity. Persons afflicted with it are perfectly aware of their condition, and able of their own motive to put themselves under medical care. A second important characteristic is that persons afflicted with it seldom labor under hallucinations. When these occur it is the result of some other form of delirium which may be present in addition to this. A third characteristic is the perpetual desire the patients experience of having their doubts quieted by the affirmation of another person. A woman, cited by M. Ritti, was always afraid that she had said or done something reprehensible. If a person who could inspire confidence in her told her nothing of the kind had occurred, she immediately became calm again. A patient, who came to consult me, expressed doubts as soon as she entered my office as to whether I was really a doctor. Upon my answering that I was, she asked permission to inquire of the persons who were waiting in the parlor if I really exercised the medical profession. Sometimes patients of this class, after having solicited reassuring affirmations and having exhausted all the forms of question that imagination could suggest, add the demand, "Will you write it down for me?"

One of the most curious instances of this whim is related by M. Baillarger: A man about sixty years old had a passion, whenever he went to the theatre, for becoming acquainted with everything relating to the actresses he saw. He would want to know their age, their address, their family position, their ways of life, their habits, and their responsibilities. Tormented by this fixed idea, he had to deprive himself of the pleasure of going to the play. Soon, however, the

same idea manifested itself relative to all the women he met, provided they were pretty. He was obliged to have a person follow him, whose duty it was to satisfy him on this point. Every time he met a woman he repeated the eternal question, "Is she pretty?" The attendant would answer "No," and that would cut short the otherwise interminable series of his questions. One day he was starting by railroad for a distant point, and in his hurry forgot to begin his observations on the woman who sold the tickets, and also to ask if she was pretty. When he reached his destination, in the middle of the night, he asked his companion if that woman was pretty. The companion, being for once worried, tired, or forgetful, answered that he had not looked at her, and did not know anything about it. This was enough to cast the patient into such a condition of anxiety that he had to start back immediately for Paris to assure himself as to the truth in the matter!

If I have been able to give a general idea of this curious mental disorder, it will be agreed that, amid all its diversities, it is essentially characterized by a kind of cerebral pruriency which nothing can satisfy, and that the repetition of the same acts, the same questions, and the same thoughts, appertains to an organic phenomenon which brings up unceasingly the same impressions. In a similiar way we contend with ourselves laboriously, while dreaming, in a situation we can not bring ourselves out of, because the incessant repetition of the same physical impressions reproduces the same series of ideas. We are not finally delivered from this obsession till we wake.

The doubting folly is hard to cure, but considerable periods of remission sometimes occur, during which the patient seems to be restored to his normal condition. Unfortunately, the amelioration is seldom permanent. The brain falls back into its old habits, and the delirium begins over again. Patients who are attacked by it at the period of puberty have a better chance of recovering than others, for the progressive evolution of the organism may bring them relief from this psychologic condition. On the other side, the malady hardly ever ends in insanity. The subjects, when they have reached the last stage of their malady, remain fixed in their delirium. Incompetent for all work, sad and morose, they retire from society and live in voluntary sequestration. The prognostic is therefore extremely grave, for in the great majority of cases the future is definitely lost, whatever remissions of longer or shorter duration may give birth to slightly founded hopes.

The causes of the doubting folly are quite numerous. Heredity must be placed in the first rank; then comes puberty, which impresses a peculiar stamp on the psychoses that are brought under its influence. Sexual and intellectual excesses may also be included among the causes. Women are supposed to be more subject to the aberration than men. The disease is sometimes developed during convalescence from grave sickness. A certain part in producing it is attributed to moral per-

turbations, to lively emotions, and sudden frights. Frequently, as in the case of the patient who has been referred to so often, the origin of the disease entirely escapes us.

While suitable medical remedies are no doubt proper in their place, the principal part in the treatment should be given to moral remedies. It is, of course, useless to reason with the patient, or to try to show him how baseless his delusion is; but his attention should be engaged and his mind diverted from the set ideas that tyrannize over it, and a wisely arranged intellectual gymnastics should be prescribed. Physical exercise may also be made of service in turning to the profit of the body a little of the exaggerated activity that torments the mind. A final remedy is sequestration in a sanitary institute. It need not be applied to all patients, but may evidently be of use in cases where the surroundings, the habits of life, and the occupations to which the subject has been devoted, seem to have participated to any extent in the explosion of the psychical troubles.

THE PROGRESS OF AMERICAN MINERALOGY.*

By Professor GEORGE J. BRUSH,

RETIRING PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MR. PRESIDENT, AND FELLOW-MEMBERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: The change in the Constitution effected at our last meeting, extending the scope of the Association and dividing it into nine sections, each with a vice-president, whose duty it is to deliver an address to the section over which he presides, has relieved the retiring President from attempting a general review of the progress of science during the past year.

I turn, therefore, to a more special subject, and invite your attention this evening to a sketch of the progress of American mineralogy, since the commencement of this century, with particular reference to the labors of some of the early workers in the science on this continent.

During the last quarter of the eighteenth century, while great activity existed and rapid advance was made in the study of chemistry and mineralogy in Europe, almost nothing was accomplished in this new country. It is true that students in other departments of science, especially members of the medical profession, in the cities of Philadelphia, New York, and Boston, attempted to arouse an interest in mineralogy, believing that the diffusion of a knowledge of this science would be of the utmost importance in the material development of the

* An address delivered before the American Association for the Advancement of Science, at Montreal, August 23, 1882.

country. There were, however, no text-books to aid the inquirer. There were no collections of minerals to stimulate the student. In the absence of these it was almost impossible that an interest in this science should be fostered, or that a spirit of investigation should be awakened.

As the first distinct beginning of the science, I may mention an association formed in 1798 in the city of New York, which assumed, as they expressed it, "the name and style of the American Mineralogical Society." It announced as its object "The Investigation of the Mineral and Fossil Bodies which compose the Fabric of the Globe, and more especially for the Natural and Chemical History of the Minerals and Fossils of the United States." The distinguished Dr. Samuel Latham Mitchill, who seems to have been a man of universal genius, was at once its first president, its librarian, and its cabinet-keeper. The committee of the society issued a circular in which, while expressing themselves "desirous of obtaining and diffusing by every means in their power a correct and extensive knowledge of the mineral treasures of their country, they earnestly solicited their fellow-citizens to communicate to them on all mineralogical subjects, but especially on the following," viz. :

1. Concerning the stones suitable to be manufactured into *gun-flints:* where are they found? and in what quantity? 2. Concerning *native brimstone or sulphur* or the waters or minerals whence it may be extracted? 3. Concerning *saltpeter:* where (if at all) found native? or the soils which produce it in the United States? 4. Concerning mines and ores of *lead:* in what places? the situation? how wide the vein? in what kind of rock it is bedded?

This warlike demand seems to call more for the discovery of the materials for national defense than for the advancement of science, and, besides being a commentary on the spirit of the times, gives a rather humorous impression of their strangely inadequate conception of the science of mineralogy and its possible bearings on practical life. But in justice to them I should add that it is further announced that "specimens of ores, metals, coals, spars, gypsums, crystals, petrifactions, stones, earths, slates, clays, chalks, limestones, marbles, and every fossil substance that may be discovered or fall in the way of a traveler, which can throw light on the mineralogical history of America, will be examined and analyzed without cost, sufficient pieces, with the owner's leave, being reserved for placing in the society's collection." I have quoted the circular almost *verbatim* to give you some idea of the genuine though crude longings for knowledge felt by our early mineralogists, and also of the generous spirit in which they worked.

A still more forcible picture of the ignorance of the time is given by the elder Professor Silliman in 1818. "Notwithstanding the laudable efforts of a few gentlemen," he says, "to excite some taste for

mineralogy, so little had been effected in forming collections, in kindling curiosity and diffusing information, that only fifteen years since (1803) it was a matter of extreme difficulty to obtain *among ourselves* even the *names* of the most common stones and minerals; and one might inquire earnestly and long before he could find any one to identify even *quartz*, *feldspar*, or *hornblende* among the simple minerals, or *granite*, *porphyry*, or *trap* among the rocks. We speak from experience, and well remember with what impatient, but almost despairing curiosity we eyed the bleak, naked ridges which impended over the valleys and plains that were the scenes of our youthful excursions. In vain did we doubt that the glittering spangles of mica and the still more alluring brilliancy of pyrites gave assurance of the existence of the precious metals in those substances, or that the cutting of glass by the garnet and by quartz proved that these minerals were the diamond; but, if they were not precious metals, and if they were not diamonds, we in vain inquired of our companions, and even of our teachers, what they were."

Such, then, was the state of knowledge in mineralogy here at the commencement of the century. A few American minerals, collected by travelers from time to time, had before this been taken to Europe for identification, but among these were discovered only two minerals new to science. The Moravian missionaries found at St. Paul, in Labrador, the beautiful species of feldspar called by Werner *labradorstein*, which in more modern times we know under the name of *labradorite*. Klaproth, the most eminent analytical chemist of his time, discovered that the so-called fibrous barytes from Pennsylvania was the sulphate of the then newly discovered earth strontia. He thus, for the first time, identified the mineral species *celestite* which was subsequently found in various localities in Europe.

Although little had been accomplished in America previous to 1800, the first quarter of the new century was destined to show great development here in the study of mineralogy. During the early years of this quarter several collections of European minerals were brought to this country by American gentlemen who had availed themselves during a residence in Europe of the best opportunities for acquiring a knowledge of the science from the great masters of the subject in Germany and France. About this time also several colleges in the country had instituted chairs of chemistry and mineralogy, and a commencement was thus made in teaching these sciences in the higher schools. As the result of these influences the number of persons interested in mineralogy was largely increased, and an active search for minerals was initiated throughout all of the older United States and to a considerable extent also in Canada.

So energetically were these explorations followed up that in 1825 a "Catalogue of American Minerals" was published by Dr. Samuel Robinson, with their localities arranged geographically, and giving

only such as were known to exist in the United States and the British Provinces. It formed an octavo volume of over three hundred pages. That much credit was due to *many* workers during this period, both in the field and in the laboratory, there can be no question, but among them all I find four men standing forth so prominently as leaders that I have thought it would be well for us to recall briefly something of the character of these men and their labors for the advancement of mineralogy in this country.

First among these I will mention Dr. Archibald Bruce. He was the son of Dr. William Bruce, a surgeon in the British army, and was born in New York in 1777. He was graduated at Columbia College; subsequently studied medicine, and in 1798 went to Edinburgh, where, in 1800, he obtained his doctor's degree from that university. He was early interested in natural science, and while still in college found, his biographer says, "the collection and examination of minerals—a pursuit not then at all attended to in this country—was his particular relief from other studies; for even during his recreation he was ever on the lookout for something new or instructing in mineralogy."

When he went to Europe he took with him a large number of American minerals, and, through exchanges with institutions and prominent mineralogists abroad, he established friendly relations with those most interested in his favorite science. After the completion of his medical studies, he traveled for two years on the Continent of Europe, making the acquaintance of the Abbé Haüy, and other eminent mineralogists, and collecting an extensive cabinet of valuable minerals, which, on his return to this country in 1803, he brought with him to New York. This collection, with another brought to New York about the same time by Mr. B. D. Perkins—both being made fully accessible to all interested in seeing them—contributed, it was said, more than any agencies had ever done before to excite in the public an active interest in the science of mineralogy. Besides this, Dr. Bruce entered into extensive correspondence with others interested in the subject, was active in visiting and discovering new mineral localities, and in advising, encouraging, and inspiring young mineralogists. Finally, after well considering the matter, he established the first purely scientific periodical ever published in America. This was called the "American Mineralogical Journal," and the first number of it was published in 1810. It contained original contributions, chiefly on mineralogy, from a number of investigators. "It was received," says the elder Silliman, "in this country and in Europe in a flattering manner; it excited at *home* great zeal and effort in support of the sciences which it fostered, and *abroad* it was hailed as the harbinger of our future exertions." But alas! it was in advance of the age, and, after struggling for several years, was given up on the publication of the fourth number. Possibly it would have continued longer had it not been for the failing health of its founder.

This journal contained several important papers by Dr. Bruce; among them, the investigation and description of two new mineral species, the *native magnesia* of Hoboken and the *red zinc oxide* of Sussex County, New Jersey. These are the first American species described by an American mineralogist. So thoroughly was the work done by Bruce, that these species remain to-day essentially as he described them, and his papers may well be studied by mineralogists now as models of accuracy and clearness of statement. . . .

I have mentioned that the importation and exhibition of collections of minerals from Europe had contributed much to excite an interest in the study of mineralogy. It was necessary to have known minerals for study and comparison in order properly to determine those obtained by exploration here. In 1805 Colonel George Gibbs, of Rhode Island, for many years a resident in Europe, returned from his travels with a collection of minerals, the most extensive and valuable ever brought to America. Colonel Gibbs was a zealous cultivator of mineralogy, and, fortunately for science, a young man of wealth. He used his money freely for the purchase of whole cabinets, as well as in personal explorations in search for minerals.

The larger part of his collection was made by the purchase of two famous European cabinets: one from the heirs of Gigot d'Orcy, a noted French collector, and said to have been the result of forty years' labor; the other from Count Gregoire de Razamowsky, a Russian nobleman, long resident in Switzerland. D'Orcy's cabinet numbered over four thousand specimens, chiefly from France, Germany, Italy, and Great Britain; Razamowsky's contained about six thousand specimens from the Russian Empire, and the remainder principally from Germany and Switzerland; in all, with the other collections made by Colonel Gibbs, it is said that more than twenty thousand specimens were brought by him to this country.

In 1807 a portion of this collection was opened in Newport, and many interested in mineralogy made pilgrimages there, to view the treasures it contained. Among others was Professor Silliman, who states, in his diary, that he spent many weeks in studying the minerals with Colonel Gibbs, finding in the latter "a scientific friend and a professional instructor and guide." That Colonel Gibbs reciprocated Professor Silliman's feelings of friendship there can be no doubt, for, after various offers to deposit his collection for exhibition in Boston, New York, and elsewhere, to the great surprise of Professor Silliman, he proposed to open the cabinet at Yale College, provided rooms should be fitted up for its reception.

The proposition was promptly responded to by the authorities of the college, and in 1810, 1811, and 1812, under the personal supervision of Colonel Gibbs, it was opened and arranged, and generously placed at the disposition of the institution and the public. The opening of this collection in New Haven formed an important epoch in the history

of the college, and gave a powerful impetus to science throughout the country. It was not only studied by the pupils of the college, but it was visited by travelers from all parts of the United States.

In 1825 the collection had for fifteen years been exhibited without any advantage to the owner, other than the satisfaction of observing the great amount of good which was effected by the knowledge it disseminated and the enthusiasm with which it inspired students. Colonel Gibbs then offered the whole for sale, giving the college the preference as purchaser. Fortunately, and mainly through the influence of Professor Silliman, the institution succeeded in raising the funds ($20,000) necessary for its purchase, and the ownership of this collection has exercised a most important influence in the development of natural science at New Haven.

Colonel Gibbs, however, did not confine himself to the collection of minerals in Europe. On his return to this country he made extensive journeys and opened up new mineral localities, giving his time and specimens freely to aid others who were interested in this special study. At Yale, as an incentive to students, he for many years offered prizes for superiority of attainments in mineralogical knowledge and for services rendered to the science by useful discoveries and observations.

He published valuable papers both in the "American Mineralogical Journal" and the "American Journal of Science," and did much by his counsel and co-operation to support these publications. Indeed, it was from Colonel Gibbs that Professor Silliman first received the suggestion that he should institute a new journal of science, in order that the advantages already gained by the short-lived "Mineralogical Journal" might be secured, and further progress for science might be made. . . .

Much as had been accomplished by the free exhibition of cabinets and the explorations and investigations of enthusiastic workers in mineralogy during the years from 1805 to 1815, a great drawback was now felt to the progress of the science from the want of text-books. Most of the literature of the subject was in German and French, but the works of the French and German authors had not then been translated, and consequently were accessible only to the few who were acquainted with these languages.

In English there were not many treatises on the subject. That by Richard Kirwan, the eminent Irish mineralogist of the last century, was a renowned work in its day, but, as the last edition of it had been published in 1794, it was already too old to be of much service to the student. Jameson's treatise was somewhat more recent (1804), but its great fullness and exclusive devotion to the Wernerian system made it an undesirable book for beginners, aside from the fact that its price was such that few students in those days could afford to buy it. So much progress had been made at home and abroad, that a work

was needed here which should include the modern discoveries, and one also which should gather up the scattered facts already published in regard to American minerals.

Fortunately for the further progress of science in this country, this was done by Professor Parker Cleaveland. His work was published in 1816, and was entitled "An Elementary Treatise on Mineralogy and Geology."

Professor Cleaveland was Professor of Mathematics and Natural Philosophy in Bowdoin College, and, like many other professors of science in the early history of American colleges, was charged by the trustees to lecture also on mineralogy and chemistry. He was an enthusiastic student of mineralogy, was well acquainted with the literature of the science in various languages, had been a successful teacher of the subject for many years, and withal was both an explorer and investigator, and held intimate relations with the leading mineralogists of the day. The work was modeled on the general plan of Brongniart, combining the excellences of both the French and German schools, and gave in detail almost everything then known in regard to American minerals. It supplied the pressing need for a thorough, systematic, and *American* treatise on mineralogy, well suited to all classes of students, and it was written in such a masterly style that it won for its author the highest praise from the leading mineralogists of the world. "It brought," says Professor Silliman, "within the reach of the American student the excellences of Kirwan, Jameson, Haüy, Brochant, Brongniart, and Werner, and we are not ashamed," he says, "to have this work compared with those of these celebrated authors." His biographer states that "he received letters of respect and congratulation from Sir David Brewster, Sir Humphry Davy, and Dr. McCulloch, in England, from Berzelius, in Stockholm, Germar of Halle, from Brongniart, Baron Cuvier, and the Abbé Haüy, in Paris."

The work at once took rank as one of the leading authorities on the science, and was introduced as a class-book in the principal schools and colleges in America. The first edition was soon exhausted, and a new and revised edition, with more than a hundred pages of new matter, was published in 1822. The demand was so great that this likewise was soon out of print, and a third edition was called for by the public; but Professor Cleaveland had about this time become so engrossed in the administration of the affairs of the new Medical School at Brunswick that he was unable to respond to the call, having turned his thoughts and efforts in new directions.

Unfortunately for the science of mineralogy, in which he had obtained such eminence as an author and teacher, he no longer contributed actively to its progress, although he continued his work as lecturer on the science so long as he lived.

The last to be mentioned of these early leaders is Professor Benjaman Silliman. His name is so intimately associated with the progress

of science on this continent during the first half of the present century that his life-work is more or less familiar to all. But the important service he rendered in the early history of mineralogy deserves especial recognition here, not only for the work he himself did in the laboratory and the field, but because his enthusiasm and zeal were a constant inspiration to others.

Commencing with the historic "candle-box" of unlabeled stones which he took to Dr. Adam Seybert, of Philadelphia, to be named, he began with enthusiasm the acquisition of knowledge and the gathering of material to illustrate the mineral kingdom. During a residence in England and Scotland, in 1805–'6, he had opportunities to add to his information, and collect many specimens, chiefly from the mines of Derbyshire and Cornwall. On his return to America he at once applied the knowledge he had acquired in making an exploration of the mineral structure of the environs of New Haven, and read a paper on this subject to the Connecticut Academy of Arts and Sciences in September, 1806.

In the following year he induced the corporation of the college to purchase the mineral collection of Mr. B. D. Perkins, of New York (already referred to), for one thousand dollars, thus placing the institution in possession of means for illustrating the science of mineralogy far in advance of anything it had before enjoyed.

The occurrence of the fall of the Weston meteorite in December, 1807, offered an opportunity for Professor Silliman to undertake, in connection with his colleague, Professor Kingsley, an investigation into the circumstances of the phenomenon, and the character of the stones which fell at that time. The results of this investigation were presented to the American Philosophical Society, and published in the "American Philosophical Transactions," in 1809. The diligence employed in obtaining all the facts possible from eye-witnesses of the occurrence, and the care and skill shown in the chemical and mineralogical examination of the meteorite, made this paper one of the most remarkable memoirs of the time, and attracted the attention of philosophers throughout the world.

As already stated, it was the personal enthusiasm and magnetic influence of Professor Silliman which led Colonel Gibbs to deposit his great cabinet of minerals in New Haven, under the care of his friend. It was due to the same qualities in Professor Silliman that the college secured the permanent possession of this invaluable collection, which probably has done more to create an interest in and disseminate a knowledge of mineralogy in this country than any other single agency.

The establishment of the "American Journal of Science" in 1818, now everywhere recognized as of inestimable value to all departments of science, was peculiarly helpful to mineralogy, and the early volumes are rich in articles on this subject. Professor Silliman's original contributions to science were more in chemistry and geology, but he also

is the author of several important papers on mineralogy, and was the discoverer of the occurrence of native tungstic acid as a mineral species. For more than fifty years he continued as teacher in Yale College, and when he resigned his professorship, in 1853, he had the satisfaction to have as his successor in the department of mineralogy and geology Professor James D. Dana, who was already among the foremost mineralogists of the day, and whose published works, before and since his accession to this professorship, have done so much for the advancement of mineralogy. . . .

It will be inferred from what has been said of these pioneers that the developments and discoveries of minerals, during the first twenty-five years of the century, were due entirely to individual enthusiasm and private enterprise. Up to this time no aid had been received from either State or national governments, and in looking over the work accomplished during this period we are filled with wonder and admiration at the energy and rare devotion to science exhibited. The larger portion of the continent was an unbroken wilderness, and the facilities of communication even in the settled parts of the country were of the most primitive character. Yet at the present day, with our means of rapid transportation, many naturalists would hesitate to undertake the long journeys then made for purely scientific purposes.

Geologists as well as mineralogists will recall how much science is indebted to such men as William Maclure, James Pierce, Thomas Nuttall (the botanist), and others who made extensive trips through the whole territory east and in some instances to the west of the Mississippi River. Maclure not only devoted his time and money to making and publishing a geological survey of the United States and Canada, the first report of which was made in 1809, but to him the Academy of Natural Sciences, in Philadelphia, owes its first endowment.

I shall be pardoned, I trust, if I mention still another signal instance of private liberality in this connection. General Stephen Van Rensselaer, of New York, a generous patron of science, defrayed all the expenses of a geological survey of the country adjacent to the Erie Canal, including the making of a geological section from Lake Erie to the eastern coast of Massachusetts. This survey was under the charge of Professor Amos Eaton, with a competent corps of assistants, and was continued for four years, from 1820 to 1824, at a cost of many thousands of dollars. General Van Rensselaer was also the founder of the first school of technical science in this country—the Rensselaer Polytechnic Institute, at Troy, which was placed under the charge of Professor Eaton. It may be interesting here, in these days of summer schools, to recall, although parenthetically, that what was probably the first Summer School of Science in the United States was established more than fifty years ago in connection with this institution. The school consisted of a flotilla of towed canal-boats, and the route was from Troy to Lake Erie. It took two months for the trip, and visited

all important points on the way. Instruction by lectures and examinations was given in mineralogy, geology, botany, zoölogy, chemistry, experimental philosophy, and practical mathematics, particularly land-surveying, harbor-surveying, and engineering. One of the largest boats in the flotilla was fitted up as a laboratory, with cabinets in mineralogy and geology, and also scientific books for reference. Students were taught the method of procuring specimens, and were required to make collections of whatever was interesting on the route.

The public mind was finally awakened to the importance of the work which these explorers and investigators had carried on single-handed. Government now came to the aid of science. In 1824 one State Legislature, that of North Carolina, authorized a geological survey to be made. This example was followed in 1830 by Massachusetts, and soon after by New York, Pennsylvania, Virginia, and other States, and also by the national Government, until, as is now well known, the whole territory of the United States and Canada either has been or is in the process of being surveyed. Several of the State surveys published independent volumes on the mineralogy of their respective States, and these surveys have been a powerful auxiliary in extending our knowledge of the occurrence of minerals on this continent. The opening of mines and quarries throughout the country has also furnished abundant material for study. The large number of original contributions which have been published in the volumes of State surveys, the treatises by American authors, and the still larger number of memoirs and papers communicated to our academies of science and scientific journals, can not be even enumerated in this place; neither is it my purpose to attempt to give here a list of the names of those who have been actively engaged in making researches on American minerals. Still less can I attempt to give an account of the work that has been and is being done by living mineralogists. The sketch which I have presented of the four typical workers has in a measure shown the character of our early mineralogists, the earnest spirit in which they labored, and what they accomplished in the first quarter of the century. The point to which the science has reached in the last quarter of the century can not be unfamiliar to you all.

In the time that remains I desire to call your attention to some of the developments made in the field in which our mineralogists have worked. It was thought by many scientists in the first half of this century that our rocks seemed likely to afford less variety of mineral contents than the rocks of Europe. Further study, however, and more careful and extended observations, encourage us to believe that our mineral riches, even in variety of species, will compare favorably with those of other continents. Already fully one half of the known mineral species have been found here. The present number of known minerals is variously estimated to be from seven hundred to one thousand. There have been described, as occurring here, nearly three hun-

dred supposed new American minerals. Of these, perhaps one quarter are new to science, and the remainder have either been proved to be identical with species already described, or their characters are so imperfectly given that further investigation is needed to ascertain what they are. Among these new minerals are some of great interest to science. . . .

In comparing the minerals found in America with those of Europe, although interesting minor variations are observed, it can hardly be expected that very marked differences should exist. This is, of course, due to the fact that, in the inorganic kingdom, Nature has everywhere to do with the same elements, under essentially like conditions. A large number of remarkable analogies between the minerals of the two continents will occur to any one familiar with the subject, as, for example, the character of the occurrence of individual minerals in the rocks of the Northeastern United States and Canada as compared with those of Norway and Sweden, and numberless instances of like association of minerals in various parts of Europe find their counterparts here.

A marked feature of American minerals is the grand scale upon which crystallization has taken place, individual crystals of large size being very common. The granite veins of New England afford striking examples of this kind. We have common mica, in sheets a yard across; feldspar has been observed where a single cleavage-plane measured ten feet; gigantic hexagonal prisms of beryl, four feet long and more than two feet in diameter, and weighing over two tons, have been described; spodumene crystals, six to seven feet in length and a foot or more across, and masses of rock-crystal of immense size, have been found. Canada and New York have given crystals of apatite, phlogopite, and sphene, which for these species are of marvelous grandeur in dimensions. Many other American localities might be mentioned where giant crystals occur. While it is true that these are extraordinary instances, it is also true, as a general fact common to a very large proportion of the minerals found in this country, that the species occur in much larger crystals than those obtained from European localities.

Another point worthy of note is the occurrence in comparatively large quantities, and over wide areas, of some of the rarer elements as constituents of the minerals found. In illustration of this we have, among the rare earths, *glucina* combined with silica and alumina in the mineral *beryl*, occurring in large quantity and perhaps in a hundred or more places; *zirconia*, in the mineral *zircon*, is also very widespread in its range of occurrence as an original constituent of the older rocks, as well as a vein-mineral; localities are known which have furnished this rare species by the hundred-weight. The *cerium* earths are found largely in the mineral *allanite*, which occurs in so many places that it may be said to be a common mineral in the United States. These earths are also found in the rare phosphate *monazite*, a

mineral that in America has a wide range of localities, and recently this species has been found in crystals of two, three, and, in one instance, of eight pounds in weight. Again, three new earth-metals —*mosandrum*, *phillipium*, and *decipium*—have been described as occurring with the cerium earths and yttria in the North Carolina *samarskite*. The rare alkali metal *lithium*, sometimes associated with the still rarer metals *rubidium* and *cæsium*, is found not only of widespread occurrence in our lithia micas, but the mineral *spodumene*, containing from five to eight per cent of lithia, occurs by the ton in at least one locality, and must be looked upon as one of the common American minerals, being found in the granite veins in Maine, New Hampshire, Massachusetts, and Connecticut, and as far south as North Carolina and Georgia. Lithia also is one of the constituents of the phosphate *triphilite*, and there are several localities known where this mineral occurs abundantly. Again, we have the frequent occurrence of some of the rare metals which form metallic acids: *Columbium*, the first metal, new to science, discovered in America, associated with its twin metal *tantalum*, is found in columbite in our granite veins from Maine to Georgia, a range of more than a thousand miles, in a score or more of places, and sometimes is obtained by the hundredweight at a single locality. The American variety of *samarskite*, another rare columbate, has also been found in masses of fifty pounds or more in weight, and these acids occur in still other American species. *Molybdenum*, both as sulphide and in the oxidized form as native molybdic acid and molybdate of lead, is found in many localities, and occasionally in large quantity. Quite recently *vanadium* compounds have been discovered in several places, and *tungstates* have also been observed over a wide range of country. *Titanium* has been found in enormous quantities in extensive deposits of titanic iron as well as in the form of rutile and in sphene. The rare metal *tellurium* occurs native in Colorado in one locality, where single masses of twenty-five pounds in weight have been taken out, and several new tellurium compounds have been found in our Western mines.

It is, perhaps, unnecessary to enumerate more fully the many occurrences of other rare elements in American minerals. Enough has already been said to show that important developments have been made in the discovery and investigation of the minerals found in our American rocks during the past eighty years. Nevertheless, it is but a commencement in the work. Only a very small portion of our territory has been explored with any thoroughness, and none of it exhaustively. The enormous production of the precious metals and the extensive deposits of ores of the more common metals which have been opened up during the past twenty or thirty years have placed us in the front rank as metal-producers, but we are still far behind Europe in the variety of minerals obtained from our mines. This may be due, in some instances, to the character of the veins or ore-deposits, there

being, as in many of our gold and silver mines, remarkably few associated minerals. In other cases, however, it is doubtless due to the fact that very few persons connected with our mines have even an elementary knowledge of the rudiments of mineralogy, while in continental Europe almost every mining officer is familiar with all the ordinary minerals. Thanks to the training of our schools of science, an improvement in this respect is already noticeable, as is shown in the discoveries made in the mines of our Western States and Territories during the past few years.

While the service done for mineralogy by our geological surveys is gratefully acknowledged, we feel that we have a right to demand much more from them in the future. Mineralogy has been too largely looked upon as a guide to the discovery of useful ores and minerals, and not as a matter for scientific study; fortunately, during the past decade the discoveries in optical mineralogy and their importance in the determination of the constituent minerals of the crystalline rocks have led many geologists to again recognize the desirability of a knowledge of our science. Much will be accomplished if those in charge of geological surveys will direct competent persons to make observations, not only on the main mineral constituents of rocks but also in the manner of occurrence of individual minerals. The careful inspection of quarries and mines is greatly to be desired. These are rich sources for minerals, but, unless constant watchfulness is exercised, valuable material for science is in danger of being buried out of sight.

It is too true that many of the most interesting discoveries already recorded seem to have been due more to the result of fortunate accident than of systematic and intelligent exploration. If our trained mineralogists, instead of devoting most of their attention to the examination of specimens in cabinets collected by others, would give more time to personal observation in the field in the study of the order and manner of occurrence of mineral species in place, our knowledge would doubtless be greatly promoted. Again, if our wealthy amateurs could be induced to spend their money as freely in the exploration of promising American localities as in the importation of costly European specimens, we might hope for many important discoveries, and they could have the satisfaction not only of gaining novelties for their collections, but incidentally they would do much to foster science.

In order to keep pace with the progress of the science, we need many more workers who will devote themselves especially to mineralogical research, and we need more of the spirit of the early workers. It is my belief that the number of persons at present interested in the study here, either as amateurs or investigators, is relatively less than in 1825. The mineralogy of to-day is a very different subject from the mineralogy of the commencement of the period over which we have so hastily glanced. Then the study of minerals was confined almost exclusively to their external characters. Led by Werner and re-enforced by his

most gifted pupil Mohs, the majority of mineralogists claimed mineralogy to be a purely natural history science. They gave their attention, as has been well said, entirely to "*how the mineral looked*," and not at all to "*what it was*." On the other hand, the development of analytical chemistry by the labors of Klaproth and Berzelius led many to take up mineralogy from a purely chemical stand-point. These two schools working independently brought great confusion into the science. The discoveries of Haüy in crystallography, and especially his labors in establishing a mathematical foundation for the geometrical form of crystals, and the recognition that the constancy of form depended on the constancy of the "integrant molecule," were steps which paved the way for modern mineralogy. In this a union of all the physical, geometrical, and chemical properties is required in order to determine the true character of a mineral.

Further, we are called upon to investigate the history of its origin, its relation to associated species, the changes which it undergoes, and the causes and results of these changes. Here we have to do largely with both geology and chemistry. From this it becomes evident that a much broader foundation is now required for the mineralogist than in the early days of the century. The bearing of physics, geology, and chemistry, in the study of the mineral kingdom, must be thoroughly recognized and appreciated by every investigator who desires to contribute to further progress. No mineralogist can expect to have a profound knowledge in all these directions, but he must be at least capable of intelligently applying to his subject the results obtained by experts in these sciences. Mineralogy is deeply indebted to special investigators in all these departments. Without their co-operation it would have been impossible to discover the relations of form and other physical characters with that fundamental arrangement of molecules whose nature it is now admitted controls all the properties of a substance.

The study of natural crystals has yielded rich material for the physicist. In the department of optics it has given results from which many fundamental laws have been deduced; and natural crystals, too, have furnished, in many cases, the very apparatus which made investigations possible. Some chemists claim that mineralogy is not at all a science by itself, and constitutes only a small part of inorganic chemistry. It can be unquestionably conceded that a knowledge of chemistry is fundamental, and in consequence this claim has a certain plausibility. On the other hand, we contend that it was largely the labors of the mineralogists on the physical characters of minerals, and especially their demonstration of the relation of form to chemical composition, which finally awakened chemists to a more profound study of their own subject. The law of isomorphism was discovered by a chemist, whose training as an expert crystallographer in the examination of natural crystals made it possible for him to recognize the wonderful relation of form to composition. Dimorphism was first established

from observations made on minerals, and it is in the study of the mineral kingdom that the laws of isomorphism and dimorphism find abundant demonstration. From the further investigation of the chemical nature of minerals we may hope for new light on the molecular constitution of substances which as yet the chemist has been unable to reproduce. We have already indicated the interdependence of geology and mineralogy. May we not claim the same interdependence of mineralogy, physics, and chemistry, letting each go on in its own sphere, contributing to the general progress, sure that every new fact observed and every new law discovered will be for the common advancement of all?

INDUSTRIAL EDUCATION IN THE PUBLIC SCHOOLS.*

By Professor H. H. STRAIGHT.

THERE is a growing feeling among the students of industrial problems that our whole conception of education in general, and of industrial training in particular, needs revision and enlargement. This feeling is based upon such easily observed facts as the following:

1. Paupers are on the increase.

2. Our schools too often educate their pupils out of harmony with their environment, thus justifying the charge that education (falsely so called) unfits its possessors for useful industry.

3. The simpler and less important positions in the world's workshop are as a rule greatly overcrowded, while in the upper stories there is a vast amount of unoccupied space.

4. The work done in the lower stories is often exceedingly shabby.

5. Many who aspire to the upper stories fail to enter—or, if they apparently enter, soon end in failure.

6. The chosen few who truly enter, and build up magnificent industrial fabrics, with the splendid fortunes which such fabrics imply, fail to educate their children to carry on their good work, or to do work of similar value in some other department of useful industry.

7. A whole community of prosperous workmen may be well-nigh reduced to beggary by the incoming of some new invention, or by change in the fortunes or tastes of consumers.

8. When old industries are swept away, and new ones established on the wrecks, there is usually little power on the part of workmen to adapt themselves to the new conditions.

9. The relentless law of the survival of the shrewdest and most unscrupulous, instead of the Christian law of mutual consideration and

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co-operation, too generally prevails among individuals and all kinds of human organizations.

That all education should be industrial, and that everybody should be industrially educated, we believe to be a perfectly tenable proposition. For one to be industrially educated he must be in possession of the following elements:

1. An industrial disposition, which leads to a cheerful and even happy devotion to some chosen employment, as the avenue through which to make his contribution to the world's wealth.

2. Industrial knowledge—such general and special knowledge as will put him in possession of the best human experience in the direction of his chosen vocation.

3. Industrial power—such a development of physical, intellectual, and artistic power as will remove as far as possible the chances of failure, and, by giving a just consciousness of strength, will enable him to work always with the hope and expectation of success.

Will not all admit that it is at least desirable that such education should become universal?

In the brief time at our disposal, we can scarcely outline the place the public schools should occupy in the development of such a scheme and in the accomplishment of such results.

How can the industrial disposition be fostered? How can industrial knowledge be most economically and efficiently imparted? How can industrial power be developed? How can the different classes of the world's workers be brought into intelligent sympathy?

These are the great questions pressing for solution upon society in general, and upon the teacher in particular. Probably no friend of industrial education would claim that farmers, mechanics, or artisans of any kind, as such, should be fitted for their special work in the public schools, any more than that these schools should undertake the training of physicians, lawyers, painters, sculptors, statesmen. The public schools should rather form the road leading up to the base of the mountain of industry and art, thence branching to the various heights of the special industries, each special height having at its base a special school to fit its students for its climbing.

As all classes of our people are to be citizens of one common republic, popular education must extend sufficiently far to prepare for the one great common industry of citizenship. The power to read, write, and cipher, may be destructive or helpful to good citizenship, according as it is or is not guided by an intelligence suffused with conscientious regard for the rights of all men. This intelligence and regard can be developed only as the work of the schools is based upon a sound platform of principle. We believe this platform can be made so broad, so catholic—that its inherent naturalness and divinity shall be so readily apparent—that men and women, who desire to make united effort for the good of all, can easily stand upon it.

In the first place, the schools must recognize the true nature and place of the industrial instinct: that it is the creative instinct; one of the profoundest of the human soul, and one of the earliest to manifest itself. The plays in which the child finds his greatest delight are all embryo industries. My little two-year-old, who with his blocks and sticks builds a barn for his rubber camel, is as truly *creating* as the architect who, with greater skill and knowedge, constructs a palace. Why should not the *joy in producing*, which forms so large a part of the child's happiness, be carried forward into the industries of maturer years, deepened and ennobled by a knowledge of industrial relations, by experience of the value of industrial products, and, above all, by the consciousness of duty done in the contribution made to human comfort and well-being? Give this instinct a proper development, join with it the best human intelligence and the best human benevolence, and you have the ideal man—the man perfect as his "Father in heaven is perfect."

In the second place, the schools must make a wise selection from the accumulated knowledge of the world. They must impart that knowledge which will enable their students intelligently to decide which one of the special heights of industry or art each is best fitted to climb. They must give that knowledge which will reduce to a minimum the difficulties in the way of change from one industry to another, often rendered necessary by the accidents of time and fortune.

All classes of citizens must have the knowledge which will form a basis for intelligent sympathy and appreciation among different classes of workers, and necessary to their action at the ballot-box, in order that each may recognize all as honorable and necessary, essential parts of one grand industrial whole.

In the third place, the public schools must develop general industrial power:

(*a.*) PHYSICAL POWER.—They must take the best physiological knowledge the age affords, and under its guidance develop a body capable of enduring all the strains and fatigues likely to be brought upon it by at least the ordinary exigencies of life.

(*b.*) INTELLECTUAL POWER.—They must impart the knowledge which it is their duty to give—according to the laws of mental assimilation—as discovered and interpreted by the best students of mental growth, to the end that mental dyspepsia may be avoided, and that the best intellectual conditions may exist for the quick and accurate solution of at least the ordinary problems of life.

(*c.*) ARTISTIC POWER.—They must give such a development of the sense of the beautiful as will enable our people, not simply to enjoy the beautiful in the objects about them, but such as will give a *finesse* and finish to whatever work they undertake, whether it be the culture of corn, the making of a coat, the building of a house, or the

painting of a picture. Every workman should have, to the largest possible degree, the fine feeling of the artist, while every artist should be recognized as a working-man.

Over all this knowledge and these powers a conscience should preside that can say "*ought*" and "*ought not*" so loudly and distinctly that its commands can not go unheeded. This work is all to be done in the schools, through the ordinary subjects, properly related and taught.

I do not believe in multiplying subjects in our school curriculum. I believe most thoroughly in reducing them. Even among the old Greeks the time came when complaint was made that the children were pestered with a multitude of subjects, all thought necessary to a proper education, and accordingly all imperfectly acquired.

The territory and the time from which the Greek drew thought were but the merest fragment of that from which thought and material come pouring in upon the modern child. All ages and all climes are pouring their accumulated treasure and filth upon him. Selfishness and ignorance, backed by the hoarded wealth of generations, combine to force into his unwilling and aching mental stomach the products alike of malicious, shallow, and noble brains. The multiplication of subjects of study in the schools of ancient Greece was accompanied by a decline of mental vigor and spontaneity.

The only hope for our future lies in a wise choice of subjects for our schools—in a wise conservation and expenditure of the energies of our children. This multiplication of subjects, it seems to us, has grown out of a lack of proper appreciation of the essentials of the great departments of knowledge and their proper relations. What God has joined together, man, partly through ignorance and partly through desire of gain, has violently put asunder. Closely connected lines of study have been isolated. Great departments of thought have been cut up into petty fields, and then each little quarter-lot so covered by rubbish that teacher and pupil alike have been starved and enslaved when they ought to have been made vigorous and free through a knowledge of the truth. Industrial knowledge consists in acquaintance with industrial materials, processes, and relations.

Industrial materials are the various natural forces together with certain substances from the mineral, vegetable, and animal worlds. Industrial processes are those operations by which crude materials are converted into forms adapted to man's deeds. Industrial relations imply the mechanism of exchange, and all those considerations dealt with in political science. Let us consider briefly the possibilities of arithmetical teaching as a means of imparting solid industrial knowledge.

It was, doubtless, a great gain in teaching the elements of arithmetic when beans, corn, blocks, etc., were substituted for abstract statement. The principles stated and illustrated by Grübe, Horace

Grant, Colonel Parker, and others, that a great variety of objects should be used in teaching number; that change from one class of objects to another sustains interest; that seeing and handling many classes of objects train the observing powers to make distinctions and classify things, are sound from the stand-points both of principle and practice. The illustrations used are all good; we only suggest what seems to us an improvement and a great gain.

During the last few years we have been experimenting with classes of children in a variety of ways. One general conclusion from these experiments is that number-lessons can be utilized in teaching children to recognize a large variety of industrial materials, and this too with a positive gain in interest and impressiveness to the work in number itself. Children can be taught in this way to recognize the common and useful trees by their leaves, fruit, wood, etc.; the common rocks, minerals, ores; the more important kinds of goods used in clothing.

The fragments to be had at the shops of the tailor, milliner, dressmaker, upholsterer, of any town, would supply, without cost, all the materials desired in this direction. Samples of these materials could be artistically arranged in numerical designs upon thin board or pasteboard and hung upon the walls for constant reference and review. It is no more difficult to say "two elm-leaves and three elm-leaves are five elm-leaves," "two sandstones and three sandstones are five sandstones," "two broadcloths and three broadcloths are five broadcloths," etc., etc., than to say "two blocks and three blocks are five blocks."

A second conclusion from our experiments is, that measures, weights, and moneys can be taught more efficiently than now, along with the early teaching of the fundamental arithmetical processes.

Number, the idea of the single and plural, enters into all our knowledge both of the external and internal worlds, from the time consciousness begins to act, until death. Our very first act of knowing is the recognition of a difference between two sensations. Distinguishing external objects into the single and plural—the one and the many, the little and the big—is one of the earliest lines of investigation for the infant and child. The work of the first few months of school-life is to bring this unconscious mathematical experience out into consciousness, and to give the child the beginning of the exact and quantitative method of study.

A child can very early learn to count twelve with the objects before him; can then learn to find the number of objects in a given group by counting; then by a single glance, when the groups do not contain a larger number than he has learned to count.

He can just as early and in the same connection learn to recognize an inch, two inches, twelve inches; can draw given numbers of lines of these lengths; can cut them out of paper, pasteboard, and wood. Similar work can be done with the foot and yard. Corresponding

work can be done with the square and cubic inch and foot. The French measures can be used exclusively, or in connection with the English. Additions and subtractions can be performed with objects of these dimensions in the same manner as ordinarily with beans and blocks. The blocks may be made of wood of different kinds. Thus at the same time and with additional interest and effect there can be taught—1. The fundamental numerical operations; 2. The recognition of the useful woods; 3. The recognition of exact dimensions and proportions.

This last would lead at once into the investigation of the *dimensions* of the school-room, the objects in it, the parts of their own bodies, etc. The sense of dimension and proportion, generally so poorly cultivated, so important in numerous arts and industries, would thus receive an early and full development.

The constant drawing of these forms and dimensions, crudely at first, but more perfectly with practice, would lay an early and solid foundation for both mechanical and artistic drawing.

Why should not children early learn to mix paints and adorn their squares and cubes with the principal colors and their simpler hues and tints; then, with this as a foundation, go on to represent nature's simpler colors in the plant, animal, rock, and sky?

Thus not only would color-blindness be detected, but the color-sense would be thoroughly developed, and the foundation laid in the knowledge and power given for successful work in numerous lines of industry. We would, then, urge the practicability of using common industrial materials, objects of definite dimensions, weights, colors, imagined values, as the objects by means of which to develop primary conceptions of number and of numerical operations—thus adding to the interest, saving time, and imparting industrial knowledge.

For advanced work in the development and application of arithmetical principles, we would use such simple scientific apparatus as we have on exhibition, or those materials which would lead at once into some principle of political economy. It is our conviction that during the time ordinarily spent by a class upon ratio and proportion, there can be given a better knowledge of these subjects, as such, than is ordinarily given; and in the same time there can be taught, by actual experiment, the law of action of the lever, the laws of vibration of the pendulum, the number of vibrations in each note of the musical scale, and still other important scientific principles. The pupil certainly will have at the end a tolerably correct idea of the mission of ratio and proportion in the scientific and commercial worlds. He will not be likely to make those failures in the application of simple arithmetical principles to scientific and commercial problems with which (I know from experience) he is at present justly credited.

The result of such a method would be to show definitely the place of mathematical science in the progress of civilization. The whole

study would be dignified and glorified as is every kind of truth, when its true place and mission are discovered.

Do I hear you say, "This is all very fine in theory, but impossible in practice"? "We can not get the apparatus—we can not find the teachers"?

As for myself, I have no time for building castles in the air which can not be brought down to earth and built of solid material. Here are a few facts of positive knowledge: For a few dollars a working-room or corner can be fitted up where all necessary apparatus can be made. There is no school whose boys and girls will not become enthusiastic in this kind of work, provided they have a little direction and encouragement of the right sort. The necessary funds for a beginning may be furnished by an exhibition, or by subscription of parties to whom the subject has been properly presented. It is our very positive conviction that for a much smaller sum than most people imagine there can be fitted up a school workshop in which the following results can be accomplished:

1. There can be made all the apparatus necessary to give a most excellent course in the elements of physical science.

2. There can be made, wholly or in part, blocks, weights, etc., whose use we have described.

3. Old bottles, test-tubes, tumblers, etc., can be graduated for the practical teaching of the liquid measures—each pupil having his own set of measures.

4. Easels, rules, etc., can be made for use in drawing.

5. Cases, shelves, brackets, etc., can be made for collections and for beautifying the room.

6. Pictures can be framed.

7. There can be made most, if not all, of the needed gymnastic apparatus, i. e., clubs can be turned, etc.

In short, the pupils can do a very large part of the work of properly fitting up the school-room, and this work can be so planned as to teach in the doing of it all the fundamental processes concerned in the various industries that deal with wood and metal. All this could be fitted into other lines of industrial work (sewing, modeling), and thus might be worked out a consistent and comprehensive scheme of general industrial training. Where are the teachers to be had? Let those who are giving their best thought to the problems of education first determine the sort of work that can and ought to be done in the schools, then let them submit their plans to the people through press and platform, and then reform the normal schools to suit the desires and demands of the people thus instructed. Consider for a moment what can be got out of a single piece of apparatus such as this system of levers:

1. There are the industrial processes concerned in its manufacture, making a smooth surface, a straight edge, a good joint, dividing

the lever into equal parts, adjusting weights, little or more work with metal, according to taste and time—the wood may be finished in oil, varnish, or paint.

2. A good lesson in form can be given upon it.

3. It affords an excellent exercise in drawing.

4. There can be performed a series of simple experiments involving no mathematics. These may be made the basis of a series of simple language-lessons, the children observing the experiments and describing what is done and the results.

All this prepares the way for experiments involving arithmetical processes and leading to the law of the lever's action. I can imagine no better way of teaching ratio and proportion than through the results obtained from this series of experiment. The stimulus, interest, definiteness of thought coming from this method would more than compensate for the extra time.

5. The story of Archimedes and the discovery of the principle of the lever would interest a class of almost any age. Nothing could be better to cultivate language and develop the historical sense than the reproduction of such stories in oral and written speech.

This illustrates the uses to which I would put every piece of apparatus in our exhibit.

There is another very important item. The *forms* in which arithmetical quantities are actually put in commerce and science should be *forms* in which they come before the children in the schools. They should learn the ordinary business forms and operations, and should get a sense of the values of industrial products, in connection with their regular work in school.

These can be taught incidentally in connection with such language-lessons as I have indicated—punctuation, forms of address, and nearly all the mechanism of writing, as ordinarily treated in works upon elements of composition and rhetoric.

During the last year, in my own teaching, I have had the reproductions of lessons in physics, geology, and natural history, put in forms of letters, advertisements, etc. The novelty added to the interest, while the many changes in the form of reproduction changed the point of view, stimulated thought, and caused the work, as a whole, to make a deeper impression.

The special value to the pupils of our schools, of the work involved in such an industrial course as we have indicated, would be:

1. The cultivation of observation and judgment, the discipline of hand and eye, obtained in this way, would not be second to that obtained in any other way.

2. The course in mathematics, together with the course in language and geography, could be made the means of acquainting them with those natural products and forces which underlie all industries and all arts.

3. They would learn in a general but efficient manner the fundamental industrial processes which underlie the more special processes of the common arts.

4. This general but genuine knowledge of materials, forces, and processes, will enable each student to choose, with a fair degree of intelligence, the industry for which he or she is fitted by special taste and power.

5. Such a course would make far easier than now the change from one occupation to another, which must ever remain an incident of growing industries.

6. It would give to each person, as employer, some power to judge of the work of the employed.

7. It would furnish a basis, in intelligence, for general sympathy and appreciation among different classes of workers.

8. The last and greatest good would be the cultivation of the industrial disposition, and the killing out of the absurd idea that our schools are free.

The schools simply represent society organized for the education of its children. Every stroke of work done in these schools has to be paid for, and at the proper time children should understand this fact, and should manifest their gratitude by doing all in their power for the betterment of the schools and the proper equipment of the rooms. This, I conceive, would form a most fitting introduction to the great industrial world, and would go far toward building up that spirit of industry and mutual helpfulness which should form the essential characteristic of the American citizen.

PHYSIOGNOMIC CURIOSITIES.

By FELIX L. OSWALD, M. D.

IF the proper study of mankind is man, it is a remarkable circumstance that the most important departments of that study are still alloyed with such an excessive percentage of spurious elements, and that their exponents persist in identifying their interests with the defense of those apocryphal parts of their doctrine. Hygiene, in the legitimate sense of the word, is simply the art of avoiding sins against the health laws of Nature, but the proposition to omit therapeutics (poison-mongery, as Dio Lewis used to call it) from the curriculum of a medical college would provoke a worse storm of protest than the first attempt to divorce astronomy from astrology. In points of ethics conservatism is a more than professional duty, yet the Rev. Mr. Freekirk, as well as Bishop Highchurch, and Rabbi Tabernacle, is tolerance in person till you question one of his mythological tenets. Phrenol-

ogy, or the art of deducing mental characteristics from physical indications, would have been recognized as a true science if its apologists had not wasted their efforts in the propaganda of their craniological crotchets.

Pliny, and his countryman Campanella, already observed that the art of interpreting the features of the human face is a universal one, practiced by unformulated but well-understood rules, ever since man tried to fathom the soul of his fellow-man. "Every one," says Addison, "is in some degree master of that art which is generally known by the name of *Physiognomy*, and naturally forms to himself the character or fortune of a stranger from the features of his face. We are no sooner presented to any one we never saw before, but we are immediately struck with the idea of a proud, a reserved, an affable, or a good-natured man. For my own part, I am so apt to frame a notion of every man's humor or circumstances by his looks, that I have sometimes employed myself from Charing Cross to the Royal Exchange in drawing the characters of those who have passed by me. I can not recollect the author of a famous saying to a stranger who stood silent in his company, 'Speak, that I may see thee.' But with all submission I think we may be better known by our looks than by our words, and that a man's speech is much more easily disguised than his countenance." Even in their present crude and incoherent condition the rules of this art of symbol-reading have a far greater interest than those of our dogmatic skull-systems, which, besides minor confirmations, lack the important one of the *vox populi*. There is a deep meaning in the humorous remark of Professor Vogt, that, "if the tenets of Spurzheim were founded on fact, instinct would have taught us long ago to finger the occiput of a suspicious stranger instead of scrutinizing his face"; and the study of a phrenological bust somehow obtrudes the idea that a good deal of this cranial topography was suggested by *verbal analogies*, such as the location of our *higher* faculties in the attic of the skull while the *baser* propensities occupy the basement, or George Combe's conception that an elongated head must denote sagacity—*anglicè*, "long-headedness." Lavater's, Winckelmann's, Cuvier's, and Dr. Redfield's observations, on the other hand, are often indorsed by a multitude of analogous impressions which social studies or self-examination has left in our minds.

The comparison of modern physiognomic theories with the opinions of the ancients suggests many curious reflections, and may frequently serve to confirm one of those semi-conscious notions of our own which we derive from experience but neglect to "formulate." "Whitish hair, which at the same time is soft and thin," says Baron Cuvier, "denotes a feeble organization, a temper yielding and easily alarmed. It is commonly combined with an oval face and gently rounded head. Such heads are never found in the descriptions of malefactors. Black, frizzled hair the ancients considered as a sign of a

savage disposition." Who is not at once reminded of the timid, flaxen-haired inmates of our infirmaries and orphan asylums, and, on the other hand, of the "black, frizzled hair," so often combined with a bowie-knife and horse-pistol in the make-up of a prominent border-ruffian? And is it not confirmed by national as well as individual characteristics, that prominence of the canine teeth indicates pugnacity, or, as Dr. Carus terms it, "the love of overcoming"? The Bedouin Arabs and the Arizona Apaches have such teeth, and the physiognomies of Western hunters and teamsters and West Indian smugglers show that they are developed by adventurous pursuits.

If the experience of mankind is competent to interpret facial indications, some of the "propensities" and "perceptives" which Spurzheim lodges in the back rooms of his pan-sensorium must have a *penchant* for changing their quarters. "Firmness," for instance, which he locates in the posterior part of the upper head, undoubtedly manifests itself in the prominence of the *chin*. "Draw a face in profile," says Winckelmann, and observe how timidity or its opposite can be expressed by the shape of the lower jaw. Let the chin be receding, and your profile can be made to express pusillanimity and feebleness of character, even to the degree of imbecility. Then, without changing any upper line of the profile, combine it with a prominent chin, and it will exhibit firmness. Exaggerate the prominence, and you can intensify that expression to one of obstinacy and ferocity. That such contrasts are less striking in living faces is owing to the circumstance that we take in the expression of all features at a single glance, without analyzing the complex effect."

Have we not here a positive criterion, a rule without an exception? Does it not occur to us, on after-thought, that *all* warlike, aggressive nations have such projecting chins, while the weak or degenerate ones are more or less chin-less? In their classification of the North American aborigines the Spaniards distinguish between *Indios mansos* and *Indios bravos* (tame and savage Indians). The former comprise the different agricultural tribes of Central and South America, ignorant but harmless creatures, who subsist on a vegetable diet; the latter the carnivorous savages of the North, who divided their time between hunting and warfare. In their physical characteristics these various tribes of the American autochthones could hardly be distinguished, if it were not for a slight variation in the color of their skins and a very marked difference in the shape of their *chins*. Our redskins *have* chins, though they can not emulate those of the Indo-Germanic race; the Indians of Mexico and South America have none. In the profile of a vegetarian Indio from the neighborhood of Vera Cruz, the lower jaw recedes in a sharp line from the mouth to the throat, so that his nose, though not excessive in size, becomes ridiculously prominent. Obstinacy with a projecting chin and shrinking timidity with a receding one are here strongly contrasted, and the study of individual faces proves Winckel-

mann's rule to be almost, if not altogether, infallible. Can Professor Fowler point out a corresponding difference in the shape of the posterior skull? "Amativeness," too, may or may not affect the bones above the nape, but Theophrastus, Galen, Della Porta, Lavater, Dr. Redfield, and all portrait-painters, agree that it *is* disclosed by the *eyelids*, especially the lower ones.

Lavater and other critical students of the human face have shown the fallacy of some popular notions—for instance, the connection of a high forehead with superior intelligence—but also that generally received opinions differ less in different nations and ages than should be supposed; and it is surprising of what minute symptoms even the ancient nations have taken cognizance.

There is, indeed, hardly a facial muscle that has not been suspected of betraying mental peculiarities. "A forehead loaded with wrinkles" Aristotle supposes to indicate a gloomy, morose, and overbearing disposition, and furthermore thinks that, if these wrinkles are massed over the eye, it denotes cruelty. According to Galen, a depression in the center of the forehead announces a melancholy temper or a recollection of an awful crime, though he admits that physical excesses may produce the same effect.

"Vertical incisions in the *bone* of the forehead," says Lavater, "belong exclusively to persons of uncommon capacity and to independent thinkers." Perpendicular *wrinkles* he holds to be the emblems of wrath, because such furrows are formed in the paroxysm of that passion. If the forehead is crowded with horizontal wrinkles, it may indicate ferocity or severe mental application, but their entire absence can only be the effect of a cheerful disposition.

"If the frontal bone is convex," says Huart, "it indicates an undeveloped mind; all infants have such foreheads, and, under the influence of culture, the curve gradually disappears." Winckelmann indorses this notion, and thinks that the more straight lines the forehead exhibits the more judgment it will indicate, but at the same time so much the less sensibility. Wrinkles lengthwise between the eyebrows, Huart interprets as a sign of habitual melancholy reflections, and he, as well as Lavater and Redfield, believes that the prominence of the bone immediately above the eyebrows denotes aptitude for long-continued mental labor. "If asked what a *low* forehead denotes," Dr. Carus remarks, "I should say a vigorous scalp, or a predominating lateral development of the skull, but certainly not a low degree of intelligence"; and Horace went so far as to celebrate a *frons tenuis* as a sign of an ingenious mind.

"Gently arched eyebrows," says Campanella, "accord with the modesty and simplicity of a virgin; rough, irregular ones are the signs of ungovernable vivacity," and Dr. Redfield adds that on this point the physiognomists of all nations agree. If the hair of the eyebrows is thin or begins to fall out, Dr. Haller regards it as a sure

symptom of failing vitality; very heavy eyebrows, on the contrary, he takes to be a mark of redundant potency and reserved strength. "Eyebrows which join each other," Lavater remarks, "were considered among the ancients as a sign of a fallen character," but he himself inclines to Goethe's opinion that they denote *energische Sinnlichkeit*, which does not exactly mean sensuality, but rather active vigor of all the senses. The deficiency or abundance of eyebrow-hair he holds to be a physical rather than mental symptom, but owns that he "never saw a profound thinker, or even a man of a firm and judicious mind, with slender eyebrows, placed very high."

As to the eyes themselves, opinions differ to a rather perplexing degree. Their protuberance Gall, Lavater, and Fowler hold to be a mark of a retentive memory and language, i. e., fluency of speech, while Winckelmann and the Latin sages consider it as a sign of stupidity. A large eye the Greeks admired as the token of a large soul, but Gall and Dr. Carus see in it nothing but a large share of curiosity. The horizontal extension of the eye, if abnormal, Lavater suspects to be an indication of a designing mind; Redfield of excessive caution.

Their color, too, has been interpreted in very different ways. The ancients of Southern Europe, of course, preferred their own black eyes, and depreciated every lighter shade as sickly or even unnatural; but already, before their final subjugation by the Goths, they had learned to make an exception in favor of a blue iris, and we are told that, at last, even the dandies of the Roman capital envied the bright blue eyes and brown locks of Alaric. Gray and light blue, according to Le Brun, indicate coldness, but a German rhymed proverb calls a blue eye a pledge of good faith, and associates a gray one with deceitfulness. Brown, according to the same doggerel, bespeaks love of fun and mischievous merriment, while Spurzheim informs us that he found that color generally combined with a good-natured disposition. Only in regard to red eyes all nations and doctors agree: they are a sure sign of staminal weakness and degeneration.

In a treatise on physiognomy, the NOSE deserves a special chapter. "There is infinite expressiveness in every bone and every muscle of that prominent organ," says Sir Charles Bell, and proceeds to give us a long list of "indications," which may be summarized in the general remarks that he considers a long and pointed nose a sign of foxy slyness, a broad, short one a mark of a plain, practical mind, and Calmuck nostrils a symptom of frog-like stupidity. Redfield, too, locates "inquisitiveness" at the tip of the nose, and critical acumen in the next neighborhood, and quotes Aristotle, who speaks of the critical resources of a powerful and pointed proboscis.

In Seneca's language, an Athenian nose is a synonym for wit; and Horace introduces a wide-awake individual as a *homo enunctissimæ naris*, a man whose nasal ducts are in first-rate working order. Plato records his respect for a man with a *royal* nose, an article of which he

himself was a little short, though not to such a distressing degree as his master Socrates. Cæsar, Trajan, and the Abassides had such noses; also Henri Quatre and the founder of the Hapsburg dynasty. Rudolph von Hapsburg, though a righteous man and of peaceful disposition, so aggravated the German nobility by the size of his nose that his election to the imperial dignity gave general offense, and even men who had favored his nomination on account of his brilliant record were scandalized after meeting him face to face. But the emperor's judicious administration soon made his face so popular that he was besieged by portrait-painters, and once exclaimed in dismay: "God help me! Every fool who can draw a big nose wants to take my likeness!"

The Latins called such men *nasones*, and Ovid's influential family carried that name as a patronymic. Large hooked noses, according to Cuvier, Lavater, and Pernetti, indicate aggressiveness, love of conquest, and acquisitiveness, and their views are certainly supported by the abnormal development of those propensities among the ancient Romans and modern Jews. "When the aggressive instincts of the ancient Italians were suppressed," says Pernetti," "their noses shrunk to their present dimensions; exceptional individuals who have preserved the martial spirit of our ancestors are also conspicuous for their vigorous noses." The family of Napoleon must have preserved these characteristics in all their pristine vigor; his nose was as aggravating as his policy, and the shape of his chin was a triumph for Winckelmann's theory.

But, after all, such noses are preferable to the other extreme, the blunt hoggish snouts of the Calmucks and Southern Russians. A *nez retroussé*, a back-turned nose, the great Frederick considered as unpardonable in a soldier or any adult male of the Caucasian race, and was as proud of his own classic profile as of his best campaign. "God made the Roman, and man made the snub," says Dr. Wells, and Lavater demands a straight or *down*-turned nose as a *sine qua non* of a good face. "I never can look at a pug-nose without painful emotions," says he; "it makes it so sadly probable that our race has degenerated. I am sure Adam was not cursed with such a feature."

With a flat nose Gall associates sensuality and a groveling disposition; Dr. Redfield, also, want of energy and even of self-respect. But Zopyrus, the Athenian Spurzheim, went so far as to denounce a bulbous nose as a sign of a semi-bestial origin, and informed Socrates that one of his ancestors must have been guilty of an inhuman *mésalliance* of some sort, and that the shape of his nose "implied a tendency to drunkenness, theft, brutality, and lasciviousness"! It might be interesting to know what Zopyrus would have said about such noses as Gortchakoff's or ex-Senator Morrissey's, or the still greater deformity which made the face of Edward Gibbon a phenomenon.

The portraits of Socrates, in spite of that defect, exhibit a face

that might pass for intelligent and manly, if not for beautiful, in our days; but, in contrast with the living models of our classic statuary, the Mongolism of his features may have appeared more glaring. The Grecian profile, indeed, has always remained the *beau-idéal* of perfect beauty. "The proof that the straight profile constitutes beauty," says Michael Angelo, "is furnished by the effect of the deviating profile. The stronger the inflection of the nose the further the face deviates from its perfect form. The Grecian nose is the most human of all features; all other noses are a compromise with animalism."

These noses, as a national type, have utterly disappeared. According to Francisco Diaz, a Portuguese historian and philosopher of the eighteenth century, the last remnant of the favored race inhabited a district northeast of Cadiz, which neighborhood their Grecian ancestors had settled some two thousand years ago. They were peaceful tillers of the soil, but their adherence to the unitarian dogmas of Mohammed involved them in the fate of the wretched Moriscoes, who were expelled by order of the Rey Católico. We shall not look upon their like again.

The muscles about the mouth are mapped out like a town-chart by Dr. Carus, and for not less than eleven "qualities" he provides lodgings in that neighborhood. Love has the under lip all to himself, but four of his relatives, clemency, pity, the love of children, and benevolence, are crowded together in the narrow dell between the mouth and the chin. Five more inhabit the upper lip and the place below the nose, while cheerfulness has reserved seats in the corners of the mouth. Tumid lips must be a sure sign of sensuality, since nearly all physiognomical authorities insist on that thesis, and even Winckelmann, who commonly has an opinion of his own, is here, at least, neutral. He admits it to be a suspicious sign, but believes that after it has once become hereditary, as among certain African and South Asiatic tribes, it denotes merely a sanguine temper. But, if the upper lip protrudes so far upward that it fails to cover the teeth, the indication is even more unfavorable; it then means lasciviousness and stupidity combined. The habit some children have of keeping the mouth constantly open is also ominous of future imbecility, if we may believe Dr. Haller. Dr. Redfield's observation about prominent canine teeth has already been referred to; deformed (because decayed) teeth may indicate indolence (as implying a neglect of sanitary precautions), but are often hereditary, like weak lungs and short-sightedness. Short and white teeth in adults, as Lavater says, are frequently combined with uncommon bodily strength, and visible interspaces between the front teeth are a favorable omen of longevity.

That the art of mind-reading is yet in its infancy is sufficiently demonstrated by some of the "general rules" which, modern as well as ancient, physiognomists have recorded as the result of careful observation.

"The smallest heads," says Aristotle, "are generally stored with the largest share of sense, and the same rule applies to other extremities. If the hands and feet are small in proportion to the size of the trunk, it betokens a refined mind, a noble ancestry." Lavater would trust only to first impressions. "If I begin to analyze features," he confesses, "I am biased by my prejudices, and persuade myself to consider a head a bad one because it exhibits features which my pet theory objects to. But there are laws of compensation which assert themselves in the *tout ensemble* impression."

"In many faces I have seen an habitual expression which at first puzzled me," says Kant, "but I have found that by *mimicking* that characteristic look my mind involuntarily turns in the direction of that person's predominating passion, and thus furnishes me a key to the problem."

"How is it," asks Dr. Haller, "that crafty and designing persons use to keep one, or sometimes both eyes, half shut? and that only children and animals are honest enough to meet your glance with perfect unconcern? To other features I look for pathological indications, but the eye alone is the mirror of the mind."

Lord Byron, in matters of that sort perhaps a better observer, seems to have formed quite a different view. "Hold on, let me see the jaw," he called out, when Shelley's body was removed from the beach of Spezzia—"I can recognize any one by the teeth with whom I have talked. I always watch the lips and mouth: they tell what the tongue and eyes try to conceal."

"Let a beginner draw a head," says Le Brun, "and the face will always bear an expression of stupidity; never one of malignity or wickedness. Is not here an important hint? Stupidity, as expressed in mind or body, is *incongruity*, while in a scoundrel the mental machinery may be well arranged and very efficient, though working in the wrong direction. Mental turpitude can rarely be discovered in the features; mental derangement—which all foolishness more or less amounts to—very easily."

The comparison of some special rules reveals even stranger contradictions. Buffon, who himself loved a well-stocked larder, accepts *embonpoint* as a safe sign of mental health. "Crazy people," he informs us, "are always haggard; harmony of the mental and moral faculties is favorable to the development of fat." Redfield, with the same plausibility, demonstrates the exact reverse. "Only stupid brutes accumulate fat," says he, "oxen, sheep, and swine. Mental activity stimulates our torpid organs, but a sluggish brain induces physical inertia and fatty degeneration. . . . Dr. Swift," he adds, "was lean as long as he applied himself to letters; he afterward lost the main part of his reason and then became plump again." "A fat, short neck," says Pliny, "announces a mind ferocious," but Sir Charles Bell distinctly tells us that it indicates good-natured laziness and love of a

good table. But the difference in national standards of beauty is still more astounding. We know that Dr. Fowler's lectures made high foreheads so fashionable that New England exquisites spared no pains to promote their rapid development—not even those involved in the removal of a handful of hair; but the perfumed dandies of ancient Rome and Syracuse were just as anxious to cultivate a *frons parva et angusta*, which Ovid enumerates among the emblems of perfect beauty. Propertius, too, speaks of the *frons brevis*, the short forehead of a comely individual, and we are informed by Aristophanes that the ladies of Athens encircled their heads with a black ribbon, so as to make the forehead appear more narrow. "*Monstrum in fronte, monstrum in animo*," was a Latin proverb which certain political adversaries applied to the enormous forehead of the Dean of St. Patrick.

Galen informs us that "a great belly betrays a vulgar mind," while among the Turks beauty is chiefly a question of avoirdupois; and the Esquimaux, according to the Rev. Hansen, value abdominal prominence as the acme of manly dignity. Torngac, the old man of the sea, the hyperborean Jupiter, they think, will be distinguished among all the heroes and minor deities of his suite by his conspicuous belly and his prominent cheeks. Yankee Doodle seems rather to incline to Galen's opinion, though we have fat men's associations, and German communities where a jolly paunch is a potent element of popularity. The Gaelic mountaineers of the last century thought corpulence disgraceful; and Byron, according to his best biographer, was ultra-Scotch in this respect. "He resolved to keep down to eleven stone or shoot himself," says Captain Trelawney. "I remember one of his old acquaintances saying, 'Byron, how well you are looking!' If he had stopped there it had been well, but, when he added, 'You are getting fat,' Byron's brow reddened and his eyes flashed. 'Do you call getting fat looking well, as if I were a hog?' and turning to me, he muttered: 'The beast! I can hardly keep my hands off him!'"

The Esquimaux, as well as the Chinese and Calmucks, are shocked at the appearance of our noses; the latter speak of a proboscis or pelican's bill, if they wish to refer to the nasal organ of an Englishman, and admire the delicacy of their own stumps. But in mediæval France more than one gifted plebeian found a *nez retroussé* an obstacle to official advancement, and the *preux chevalier* valued a vigorous hook as one of his primary *insignia nobilitatis*. Montaigne, however, ridicules this taste, and suggests that a receipt for elongating noses by artificial means would make the fortune of the inventor: "*Quel bonheur de naitre avec un pied de nez!*"

We may realize the feelings of a Calmuck mother, who, shocked at the abnormal prominence of her offspring's nose, endeavors to improve his looks by flattening the offensive feature; but it is rather difficult to understand the taste of a lady who commences her toilet by

blackening her teeth!—yet this fashion prevails throughout Algeria, Tunis, and Tripoli.

It has never been fully explained how we came to be prejudiced against red hair, though Baron Bunsen suggests that it distinguished the aborigines of Northern Europe, whose descendants have survived in Jutland and Connaught, and that at a time when these F. F.'s resisted the inroads of the Indo-Germanic tribes, and every man's hand was against them, the aversion to their national characteristics, red hair and a freckled skin, became an instinct of Norman and Saxon nature. However that may be, the existence of the prejudice can not be denied, and, in certain border districts of Sleswig where yellowish-red hair has become hereditary, the local drug-stores do a rushing business in lead combs, which have been found to change the objectionable tint to auburn. But, when the Venetian Republic was in the zenith of its power, a considerable portion of the internal revenue was derived from a tax on artificial red hair, which had become a staple of commerce, and was bought and substituted for their own raven locks by all the fashionable ladies from Trieste to Fiorenza.

St. Paul asserts that "if a man have long hair it is a shame unto him." (1 Cor. xi, 14), and, with some phenomenal exceptions, our Caucasian contemporaries seem to share his opinion, though only a century ago North America and Western Europe indulged in perukes and pigtails of stately dimensions. But the Grecian aristocrats, from the days of Theseus to the accession of the Macedonian madman, sought to distinguish themselves by the length of their hair, as the Chinese mandarins by that of their finger-nails. When Alexander marched his troops against the Persian Empire, he insisted that his Grecian auxiliaries must submit to a wholesale shearing, as in a hand-to-hand fight their pendent tresses would give the enemy an unfair advantage; and Heinrich Heine is malicious enough to insinuate that the final abolition of the *Zopf*, the orthodox Prussian pigtail, was prompted by similar considerations. "If the old lady once had you by the Zopf," he says, "all resistance ended in an unconditional surrender."

[*To be continued.*]

THE FORMATION OF SALINE MINERAL WATERS.

By M. DIEULAFAIT.

As far back as we may go in the annals of mankind, we find mineral waters occupying a considerable place in the life of the peoples, and at last reach a point when they were the object of a veritable worship. Notwithstanding, however, the antiquity of the subject, and the importance that has always been attached to mineral

waters, with the immense variety of labors of which they have been the object, the fundamental questions relating to them still remain enveloped in profound darkness. An examination of the most recent and most authoritative publications suffices to show us that, with regard to the most capital point, the origin and mode of formation of these waters, we, at the end of fifteen centuries, are not much further advanced than were the Romans. Modern science, it is true, has put the ancient nymph to flight, and driven from his sanctuary the little beneficent god that presided at each fountain; but it has not yet succeeded in raising the statue of the truth upon the vacant altar.

Mineral waters take up the substances which give them their peculiar composition, and acquire all their medical value, at greater or less distances within the globe. It is, then, for geology, the science which deals with the formation of the globe, to seek the solution of the questions of their origin.

The number of mineral springs is immense, and the variations among them seem infinite; but there exist among them certain groups which distinguish and separate themselves at the first glance. Among these we place in the first rank the saline waters, or those of which the sea is the type. This is the division which I propose to consider, and of which I shall endeavor to set forth the origin and method of formation.

It is a fact, which I may state as uncontested at the present time, that all spring-waters, whether mineralized or not, are of exterior origin—that is, are waters of infiltration derived from the atmosphere. When these waters return to the light without having met, in the strata they have traversed, either soluble minerals or gases other than those of the atmosphere, they constitute ordinary waters. If, on the contrary, they have met soluble substances or gases different from those of the atmosphere, they will return more or less charged with those substances, and will then be mineral waters. In studying them we need not, therefore, inquire about the origin of the water itself, for it comes from the atmosphere, but only about that of the saline substances which it has encountered in its course.

It has been known from the most remote antiquity that considerable masses of saline substances, generally composed of gypsum, more rarely of rock-salt, exist at numerous points of our globe. The two salts we have named are the ones that have hitherto attracted the attention of commercial and scientific men; but the saline beds are in reality of a more complex composition than is superficially indicated by the predominance of those compounds.

The hypotheses which have been proposed to account for the origin of these salts, though many, may be grouped around three principal heads: 1. Free sulphuric acid, coming up from the depths of the globe, has acted upon carbonate of lime already formed and produced gypsum. 2. Hydro-sulphuric acid, coming in like manner from the

depths of the globe, has absorbed oxygen from the air, has become sulphuric acid, and, acting upon the already formed limestone, has produced gypsum, as in the previous theory. 3. Salts already formed in the interior of the globe have been brought up to the surface partly in solution, partly sublimed. These hypotheses are all wholly gratuitous; and, with regard to the first, it is impossible to admit that sulphuric acid, already formed, coming up from the depths of the globe, should have traversed, without saturating them, the enormous thickness of the underlying calcareous beds to make gypsum in the tertiary formation. The second hypothesis is more admissible, especially since M. Dumas has found gypsum that was evidently formed in that way; but while we may easily suppose a mass of limestone, of which one part has been transformed into gypsum by the action of free sulphuric acid, while the other part remains limestone, we can not admit such an intervention of the acid in a case where the gypsum is interpenetrated in all its parts with carbonate of lime. The third hypothesis, that the saline deposits have been brought up from the depths of the globe, is only a continued appeal to those mysterious actions which figure so prominently in the infancy of all the sciences; but, besides that it explains nothing, I believe that it is a real error. My studies of chemical geology have led me to the conclusion that the salts now held in solution in the waters of the seas, the salts existing in solid masses in the strata of our globe, and those which furnish the mineral constituents to saline waters, have a common origin, and that that origin is exterior to the first strata that were formed in the consolidation of the earth.

According to the conditions assumed in the nebular hypothesis of the origin of the earth, the rocks forming the first solid envelope of our globe solidified at a temperature of between 2,000° and 2,500° Cent. (3,600° and 4,500° Fahr.). Now, according to the law of dissociation, as discovered by Sainte-Claire Deville, chlorine, sulphur, and their constant compounds, with oxygen and hydrogen, were present in the atmosphere at the former temperature, and even below it, in a state of complete dissociation; and only at a much later stage than this was it possible for chlorine and sulphur to effect combinations so as to react upon the exterior crust and form sulphates and chlorides. The sulphates and chlorides, in their turn, could have been produced only at successive and extremely distant epochs. Thus, to mention only the two chlorides which constitute the largest part of the saline substances contained in marine waters, the chloride of sodium and the chloride of magnesium; the former has been formed at a high temperature, for it can support a high temperature without suffering decomposition. But the chloride of magnesium can not have been composed until a prodigiously more advanced epoch—that is, one nearer to our own time, when the temperature of the earth had descended to about the boiling-point of water; for the chloride of magnesium can not sup-

port such a temperature in the presence of water without being decomposed.

As the process of cooling continued, the atmosphere kept incessantly yielding by condensation the water which it held, and this water kept perpetually dissolving the soluble salts which it found already present, and also those that were continuously produced by the action of the acids it bore with it. As we have already seen, these salts were sulphates and chlorides. On the other hand, the metals competent to combine with the sulphur and the chlorine were necessarily those existing in the rocks that formed the first crust of consolidation, and these metals were, as we shall be able to show, lithium, potassium, sodium, magnesium, and calcium. Now, it is these five metals which, united with chlorine and sulphur, constitute nearly the total amount of the salts dissolved in the waters of the seas. Such, to my mind, is the origin of the salts which mineralize the seas; and it is an origin wholly exterior.* Thus, from the most ancient aqueous period of our planet, from the time when its external temperature was not notably below the boiling-point of water, and from a time, consequently, before any trace of life was possible, the seas have had essentially the same composition they have to-day. Zoölogists have for a long time regarded this fact as necessary, because the animals whose remains have been found in the most ancient sedimentary beds did not differ as to their general plan from their congeners in modern seas, and could not, consequently, have lived in waters that differed sensibly in composition from the water of existing seas.

If the whole mass of chlorides and sulphates was originally dissolved in the sea-waters, then the only way we have of explaining the origin of the saline formations which exist in the sedimentary beds is to assume that they have been left by the spontaneous evaporation of parts of the ancient seas accidentally isolated from the oceans. I came to this conclusion long ago, not by a more or less intuitive suggestion, but drawn to it by the logic of facts and the ideas I am about to present. This conclusion once formulated, I have taken the consequences, as numerous as important, which it involves, and have submitted them to an experimental verification.

In approaching the experimental side of my investigations, I had first to study in its details what takes place when the waters of existing seas are left to spontaneous evaporation.

First, a very weak precipitation occurs of carbonate of lime with a trace of strontium, and of hydrated sesquioxide of iron, mingled with

* An objection may be raised to this idea, from the fact that a large number of chlorides and sulphurous products are developed in modern volcanic phenomena which we all agree came up from a very profound zone. I refer to it to state that I am prepared to meet it and have elements sufficient to show that the two orders of facts are perfectly reconcilable.

a slight proportion of manganese. The water then continues to evaporate, but remains perfectly limpid, without forming any other deposit than the one I have mentioned, till it has lost eighty per cent. of its original volume. It then begins to leave an abundant precipitate of perfectly crystallized sulphate of lime with two equivalents of water, or gypsum, identical in geometrical form and chemical composition with that of the gypsum-beds. This deposit continues till the water has lost eight per cent more of its original volume, then all precipitation ceases till two per cent more of the original quantity of water has evaporated away. Then a new deposition begins, not of gypsum, but of chloride of sodium, or sea-salt. The separation between the end of the deposition of gypsum and the beginning of that of chloride of sodium is so marked that it is utilized on a grand scale in the works of the salt-marshes. The salters allow all the gypsum to be deposited in the ordinary basins, and then run the water thus cleared of gypsum into special vessels, whereby they obtain a pure salt, which they can collect down to the very bottom of the basin after the last mother-waters have been drawn off. The deposition of pure or commercial salt continues till the volume of the water has been again reduced by one half, when a precipitation of sulphate of magnesia begins to take place with it. This continues, the two salts being deposited in equal quantities, till only three per cent of the original quantity of water is left. Finally, when the water has been concentrated to two per cent, carnallite, or the double chloride of potassium and magnesium, is deposited. Spontaneous evaporation can not go much further. The residual mother-water will not dry up at the ordinary temperature, even in the hottest regions of the globe; its chief constituent is chloride of magnesium. A body of sea-water, evaporated naturally, will then leave a series of deposits in which we will find as we dig down the following minerals in order:

Deliquescent salts, including chiefly chloride of magnesium.
Carnallite, or the double chloride of potassium and magnesium.
Mixed salts, including chloride of sodium and sulphate of magnesia.
Sea-salt, mixed with sulphate of magnesia.
Pure sea-salt.
Pure gypsum.
Weak deposits of carbonate of lime, with sesquioxide of iron, etc.

The examination of this list and the facts that have been expounded draw with them a large number of consequences; I will only call attention to two of them. The first is, that the different groups of substances named in the list should become more and more rare as we ascend from the base to the summit; for each of them corresponds with a more advanced period of evaporation, and the chances for its production become less and less favorable as we rise. The second consequence—and I regard it as a capital one—is, that, when we meet one of the superior groups, we should expect to find, below it,

all the other groups which were deposited previously to it in the order of evaporation. These consequences are constantly verified in the saline beds which exist so numerously on the globe. Thus, to bring up again the two most important salts, numerous beds of gypsum are known, without rock-salt, or any of the other deposits, above them—which verifies our first conclusion; but no bed of rock-salt is known without gypsum—which verifies the second conclusion. More than this, a vast saline bed is now known which corresponds with the complete period set forth in our list—that is, with the complete period of evaporation; it is the formation at Stassfurt, Prussia, the disposition of which corresponds exactly with that shown in the list. The study of the Stassfurt bed further reveals an entirely new fact—the presence, in a part quite above the mean of deliquescent salts, of an important deposit of boracic acid combined with magnesium. All the geologists and engineers who have ever given their attention to the Stassfurt deposit have been unanimous in calling for volcanic intervention, and looking to the depths of the globe for the explanation of the origin of the boracic acid, and the place it occupies in the upper part of the bed; and they have all also given a more or less preponderant part to the play of volcanic agencies in the formation of the whole. This conclusion was the more natural, because the ordinary laws of chemistry seemed to oppose the probability of boracic acid, even if it existed, being found in the last mother-waters. Borate of magnesia is almost insoluble, and should have been among the first and lowest of the substances deposited. Adhering to the principle that there are no saline substances in the interior of the globe below the sedimentary formations, I silenced my protestations as a chemist, and applied myself to inquire if, contrary to all previsions, boracic acid did not exist in the ultimate mother-waters of the salt-marshes of the south of France. The result justified my geological induction to a degree beyond all possible anticipation. Not only does boracic acid exist in the ultimate mother-waters, but it exists there in a quantity relatively so considerable that a single drop of the water is enough to show it, either by the hydrogen method or by that of spectrum analysis. Thus, the presence of this substance in the upper part of the Stassfurt bed ceases to be an objection to the theory that the bed is purely and simply the result of the evaporation of the ancient sea-waters; and its presence here furthermore gives a confirmation, as striking as unforeseen, to that theory.

My chemical and experimental studies are very far from constituting the only foundation for my theory of the sedimentary origin of the saline formations of the globe. Existing nature offers us in abundance, and on even a vaster scale than was shown in the ancient ages, phenomena which it is sufficient to analyze to bring forth anew, even to the slightest details, the manifestations which accompanied and determined the precipitation of saline matters in the estuaries of the an-

cient seas. From among the numerous instances of this kind that present themselves to my thought, I select three—the mouths of the Rhône, the Caspian Sea, and the Dead Sea.

The map of the mouths of the Rhône shows that the lands for about twenty miles from the Mediterranean are cut up by numerous lakes, the principal of which, that of Valcares, exceeds sixty kilometres in superficial area. These lakes have been formed by the action of the alluvial contents of the river, which, being deposited on the bottom of the sea, have raised bars inclosing bodies of water. The water within the ponds, evaporating under the summer heat, is depressed in level. If the ponds were wholly isolated from each other, and had no communication with the sea, there would accumulate in each of them after a time, varying with its depth, a deposit of gypsum, and above this one of sea-salt, and so on through the series we have described; and, as the ponds are as a rule quite shallow, the saline deposits would all be thin. Things, however, do not go on thus. Most of the ponds communicate with each other and with the sea; consequently, when the water in them evaporates, the level is re-established with water that comes from the sea. In this way a pond, the bottom of which is only a few feet below the level of the sea, would become filled with saline substances if the canal of communication did not become choked. The Lake of Lavalduc, the surface of which is several yards below that of the Mediterranean, is depositing gypsum.

These facts show us saline deposits in process of formation under our very eyes, and it is not at all necessary, in order to explain their formation, to invoke changes of relief or any perturbations in the crust of the globe, but only to take an exact account of the manner in which a delta is formed, and of the circumstances that are a consequence of that mode of formation; and, although the delta of the Rhône is not one of the most extensive of the deltas of the modern period, it is one of the most remarkable and complete in respect to the spontaneous formation of saline deposits. If we should go into details, we should find a complete concordance between what is going on in the delta of the Rhône and what has been revealed in the study of the saliferous formations of past ages. Thus, saline deposits are forming in these more or less wholly isolated ponds: we have, then, a saliferous horizon in the delta of the Rhône, with the deposits generally separated; on the other hand, each of the deposits nearly always appears of a lenticular form, because the ponds of the estuaries necessarily, from the mode of their origin, assume that shape. The same principal characteristics are presented by most of the beds existing in the sedimentary deposits.

If, now, by any incident, a pond which has been closed and has deposited its gypsum is again brought into communication with the sea, life will reappear in it, and mollusks will leave their shells on top of the gypsum. If evaporation is resumed, life will disappear for a

second time, and new strata of gypsum will be precipitated upon the marls containing the marine shells. This condition is exhibited in the delta of the Rhône, where the Lavalduc Lake, which has been isolated from the sea for centuries, has sunk to fifteen metres below its level. It has a stratum of gypsum on the bottom, and above it is a thick formation of mud, that has become a true marl where it has dried, at the base of which, and at a level corresponding with the epoch at which the water was nearly normal sea-water, marine shells are abundant. It may occasionally happen that a marine estuary, in which a deposit of gypsum has taken place, shall receive an accession of fresh instead of salt water, and then we shall have deposits containing fresh-water fossils above the gypsum. We can see from this how valueless, as an argument against the theory that gypsums are products of the evaporation of sea-water, is the assertion, so often put forward in that guise, that gypsums are sometimes found covered with fresh-water deposits.

Similar phenomena and another illustration of our theory are exhibited on a colossal scale in the Caspian Sea. On the eastern side of that sea is the Gulf of Karabogaz, relatively small, but having a superficial area of at least twenty thousand square kilometres. It contains no living beings except some of the lower organisms, and its shores are marked by a complete sterility. Its only communication with the Caspian Sea is by a shallow channel which allows water to flow over from the sea, but lets none back. The excessive evaporation always going on in that hot and arid region causes a constant depression of the level of the water in the gulf, and this induces an incessant flow from the sea. In the absence of a counter-current from the Karabogaz to the Caspian, all of the salt that is brought in with the inflowing water remains in the Karabogaz; the amount of salt thus regularly added to the quantity already held there is not less than three hundred and fifty thousand tons every twenty-four hours. It is easy to prognosticate the future of this gulf. If the channel of communication is kept open, the water, now nearly saturated, will continue to deposit gypsum; but the constant accession of water from the sea will prevent its reaching for an extremely long time the degree of concentration that will permit the deposition of salt. There will in this case be produced in the Karabogaz a colossal deposit of gypsum, to which no parallel can be found in the ancient formations. If, on the other hand, the channel becomes obstructed, evaporation in the Karabogaz will go on more rapidly, for it receives no important affluent of fresh water. Then, at the end of a time which will not be prodigious, we shall have a saline deposit identical with that of Stassfurt, having large masses of gypsum at the bottom, and deliquescent salts with boracic acid at the top. The latter ending is more likely to be realized; for the level of the Caspian Sea itself is falling under the excess of evaporation over the supply of water brought by the rivers into it, and will at no very dis-

tant period sink below the level of the bottom of the channel that connects the Karabogaz with it.

The character of the Dead Sea is still in question. M. Lartet, of Toulouse, who was connected with the expedition of the Duc de Luynes in 1866, fully recognizes the close analogy of its waters with the mother-waters that are left from the evaporation of the waters of normal seas; but he believes that its waters owe their quality to thermal springs, and that the sea never could have been in communication with the Mediterranean or the Red Sea. He supports his view by the assumed absence of certain substances common to sea-waters from its waters; but, as I have found these substances by analysis in Dead Sea waters, I consider the argument resting upon that ground invalid. M. Lortet, of Lyons, has recently made a discovery that indicates that this lake once formed part of a normal sea. He has found near the Lake of Tiberias a plateau covered with gravel and rounded pebbles, situated at the exact level of the Mediterranean Sea. If the body of water that washed these gravels and pebbles once occupied the valley of the Jordan and the Dead Sea, then there once existed here a gulf like that of Karabogaz. Separated from the oceans by some accident, it has dried up; its less soluble salts have been gradually deposited in the shallower parts of the basin and constitute the saline masses which are now found in the region—products of the sea instead of being the causes of its saltness; and the deliquescent salts have become concentrated, as in modern estuaries, into the still liquid part that constitutes a mother-water fully comparable in all respects to the mother-waters of the salt-marshes of the south of France.

I conclude with a summary of the principal facts to which I have directed attention.

At the moment when the first crust of consolidation began to form around our globe, chlorine and sulphur, now existing in combinations, were in the atmosphere. When the temperature had sufficiently diminished, these two bodies, reacting on the exterior crust of our globe, formed, at intervals otherwise extremely distant, combinations (sulphates and chlorides) by uniting with the metals that existed and still exist in the rocks constituting that first envelope. These metals, combined almost exclusively with sulphur and chlorine, are precisely the ones (lithium, potassium, sodium, magnesium, calcium) that still mineralize the waters of the seas. The salts thus formed, dissolved in the waters from the most ancient age of the aqueous period of our planet, have, then, a wholly exterior origin. Later, under the influence of causes often extremely insignificant in themselves, parts of these seas have been isolated from the oceans; they have evaporated, and, according to the degree of completeness in which concentration has been effected, they have deposited salt-beds sometimes of a complex enough nature, but which have uniformly presented the typical character that they begin with deposits of gypsum. Such is the origin of

the saline masses that exist in the interior of our globe. Whenever waters of infiltration reach these saline deposits, they dissolve more or less considerable quantities of them, and, when they come out again into the light, they constitute what are called saline mineral waters.

A PARTNERSHIP OF ANIMAL AND PLANT LIFE.

By K. BRANDT.

THE fundamental difference in the feeding of plants and animals is conditioned on the presence or absence of chlorophyl. Green plants are competent to assimilate inorganic matter by means of the chlorophyl-bodies in their leaves, while animals require organic substances for food. Were this difference mere comprehensive, it would incontestably be regarded as the most important of all the differences between the two classes of organisms. But there are, on the one hand, plants that have no chlorophyl—the fungi; and, on the other hand, animals which have been known for a considerable time to contain chlorophyl, as the fresh-water sponge (*Spongilla*), the hydra, several gyrating moners, and many infusoriæ and rhizopods.

The fungi feed, like animals, on organic matters; but it is not yet sufficiently established whether the so-called chlorophyl-bearing animals can be nourished entirely after the fashion of real plants, by the assimilation of inorganic matter; or, in other words, whether, with an abundant access of air and suitable lighting, they can live in filtered water. Before we can approach this question more closely, however, we must decide another equally important one, whether the chlorophyl-bodies present in the animals are really elementary parts, morphologically corresponding with vegetable chlorophyl produced by the animals themselves, or whether they are not unicellular vegetable organisms parasitic in the animals—in other words, it must be decided whether the green bodies in animals are parts of cells or are themselves cells; whether they are morphologically and physiologically dependent on the tissue in which they appear, or independent of it.

Morphological investigation has been pursued upon hydras, spongillas, a planaria, and a number of infusoria, from which the green bodies have been pinched off and examined with strong magnifying powers. All the examinations of these different objects have given the uniform result that the green bodies of animals are not evenly green like the chlorophyl-bodies of plants, but contain colorless protoplasm besides the green mass, or, at least, a cell-kernel which can be easily distinguished on treatment with hematoxylin. Among them were likewise several cell-kernels, which were regarded as evidences of the beginning of division, for normal chlorophyl-cells never contain a cell-kernel.

Thus the green bodies of animals do not correspond with the chlorophyl-bodies of the algæ, but are independent organisms, or one-celled algæ, which have been named *zoöchlorella*. Yellow cells are found living under similar relations in actinias and radiolarias, which have been distinguished as *zoöxanthella*.

The physiological as well as morphological independence of the green cells is also demonstrated by the fact that when separated from the animals they continued to live in this condition for days and weeks, and formed starch in the sunlight. When grafted upon hydras and infusoriæ, which were quite free from chlorophyl, they continued to live upon them.

The conclusion is drawn from these researches that self-formed chlorophyl is wanting in real animals, and that, when it is present in their bodies, it originates in plants that have immigrated to them. The most interesting result from them is the answer they give to the question as to the significance of the green and yellow algæ to the animals in which they occur. In order to examine this matter more closely, colonies of radiolarii containing numerous yellow cells were put into filtered sea-water. They not only continued to live in it, but outlived the specimens that were left with the other organisms. Now, since the radiolarii are real animals, incapable of living on any but organic matter, while in this case air and water afforded them all the support they required, they could have been kept alive only by the yellow cells that lived upon them, working up the inorganic substances that were provided for them, under the influence of light, into organic. Further experiments showed that fresh-water sponges could be cultivated to the best advantage in filtered water, thus demonstrating that the *zoöchlorella* and the *zoöxanthella* are fully competent to maintain the animals in which they live. If the animals contain few or no green or yellow algæ, they are fed, like real animals, by the assimilation of solid organic matter; but, when they contain algæ, they may be fed, like real plants, by the assimilation of inorganic matter. In the latter case, the algæ living in animals perform precisely the same function as the chlorophyl-bodies of plants.

PROFESSOR RUDOLF VIRCHOW.

PROFESSOR RUDOLF VIRCHOW is almost equally well known as the leader of one of the principal German schools of scientific thought and as a prominent actor in the field of German politics. In the former capacity his name is inseparably associated with the theory of cellular pathology, which he first expounded and which he has maintained with eminent consistency; in the latter character he has gained an honorable fame as a faithful guardian of the municipal in-

terests of the city of Berlin, and as a brave and outspoken parliamentary leader on the side of liberality and progress.

Professor VIRCHOW was born at Schievelbein, in Pomerania, on the 13th of October, 1821. He studied medicine at the Frederick-Wilhelms Institute in Berlin, and was graduated in that faculty from the University of Berlin in 1843. He was made prosector of the Charité Hospital in 1846, and in the following year was appointed a regular lecturer in the university. In 1848 he was commissioned by the Government to visit Upper Silesia and study the typhus fever which was prevailing there as an epidemic, the result of misery and starvation. His report on this subject commanded attention at once, and is still held in high esteem by the medical profession and by all who are concerned with sanitary science.

To this period of Virchow's life belongs the establishment of the "Archiv für pathologische Anatomie und Physiologie und für Klinische Medicin," which was founded by Virchow and Reinhardt in 1848, and has been continued by Virchow since Reinhardt's death in 1852; and of the "Medical Reform," which he conducted in connection with Leubuscher in 1848 and 1849. The "Archiv" is still continued under Virchow's direction, and is recognized as one of the chief and authoritative medical journals of the world. To this period belongs also his entrance into active political life on the awakening of his republican enthusiasm by the revolutionary movements of 1848 and 1849. He formed a democratic club, became a popular orator, and was elected to a seat in the National Assembly, to which, however, he was not admitted, because he had not yet reached the age of eligibility. The reaction came on, and Herr Virchow, whose participation in the revolutionary movement was not agreeable to the powers whom it displaced for a time, and who had the control of the public positions he held, was removed from his lectureship. He could not, however, stay dispossessed; the medical societies insisted upon his recall, and he was reinstated by the force of his obvious fitness for his position. He accepted an invitation to the chair of Pathological Anatomy at the University of Würzburg, and removed there. The Government, however, could not spare him from Berlin, and Herr Manteuffel called him back to his old chair in the university in 1856. He then became director of the newly founded Pathological Institute, and soon raised it to the first rank among such establishments, and made it a center of independent investigations for numerous young students. While at Würzburg he published his "Collection of Contributions to Scientific Medicine," of which the leading paper, on "The Movement in Favor of Unity in Scientific Medicine," which, previously published separately, had already attracted much attention from the scientific world, revealed the tendencies and direction of thought by which his subsequent career was to be determined. Professor Virchow's most distinguished services to science have been given in the

field of pathological anatomy, in which he is generally recognized as the founder of the theory of cellular pathology. The character and value of his work in this field are reviewed by Professor Jacobi, of this city, in his address before the New York College of Physicians and Surgeons. He remarks that, before and about the time when Virchow was preparing to commence his career, medical science in Germany was by no means independent and self-governing. There was no country in Europe in which observation and regard for facts, and facts only, were less esteemed than in Germany. England had enjoyed a predilection for pathological anatomy since John Hunter. France had lived through its most brilliant medical career, and could show a roll of illustrious, sober, and painstaking men, whose successful labors had placed the medical science of that country far above the level of any other. "Meanwhile, German medicine was controlled by what was called philosophy, and mainly by the so-called philosophy of nature. . . . Everything in medicine, not accepted because it was old and traditional, was a matter of speculation *a priori* only. The bases of speculation were premises construed by reasoning, not founded on facts; by theories not built on experience, far less on experimentation. Both facts and experimentation were claimed by Virchow as the only admissible foundations of scientific medicine, no matter how long it would take to collect them or to establish them. At the same time he was perfectly well aware that the literature of the last two thousand years contained a great many available points; nobody ever was more honest in collecting material or giving credit."

Virchow wrote in the first volume of his "Archiv," in 1847: "We ought not to deceive ourselves or each other in regard to the present condition of medical science. Unmistakably, medical men are sick of the large number of new hypothetical systems which are thrown aside as rubbish, only to be replaced by similar ones. We shall soon perceive that observation and experiments only have a permanent value. Then, not as the outgrowth of personal enthusiasm, but as the result of the labors of many close investigators, pathological physiology will find its sphere. It will prove the fortress of scientific medicine, the outworks of which are pathological anatomy and clinical research."

The cell had been discovered to be the fundamental basis, by Schleiden, of the vegetable, and, by Schwann, of the animal tissues. Virchow, after a series of observations and experiments, became convinced that the cell had the power of propagating and multiplying itself within the individual, and proved that it is the physical body "with which the action of mechanical substance is connected, and within which the latter can retain its functions, which alone justify the name of life. Whatever outside of the cell acts upon it, works a mechanical or chemical change within it, which change is disorder or disease." The external cause may excite a reaction within the cell, when it works as an irritant, or it may go without reaction, when it

is a simple lesion or a source of paralysis, the difference in results being dependent upon a difference in the condition of different cells. This difference in the condition of the cell forms its predisposition. Previous to this, the old humoral theories which regarded the whole compound mass had held more or less sway in medical practice, and the recognition of diseases as local anomalies had made but slow progress. A few workers, from Vesal and Paracelsus down, had gradually given shape to the local theory, and Virchow claimed that his cellular pathology was a consistent carrying out of the principles they had established. In it the localization of disease was taken as a necessity, and its seat was fixed in the smallest composing element, or the cell. Therapeutics have also undergone important changes in the light of this theory, and under the guidance of experimental methods, and have become vastly more exact and efficient, and local in application. Thus far, Dr. Jacobi asserts, every new discovery of pathological facts has found a ready explanation by the cellular theory and its methods. "The changes worked in and by the white blood-cells, the transmutation of epithelial cells into benign results or malignant growths, the influence, real or imaginary, worked by bacteria, have but strengthened its plausibility."

An antagonism to Virchow has apparently been assumed by some of the partisans of the bacterial theory of infectious diseases which has no real basis for existence. No discrepancy need exist between a theory which regards disease as a disorder of the cells and the one which finds in the bacteria an external agency provoking and promoting cell-disorder. The publication of an essay on parasitic plants, in the first volume of Virchow's "Pathology and Therapeutics," in 1854, shows that his attention had been directed to the subject even then. In 1856, also, a paper was published by him, in the "Archiv," on the botanical nature and classification of some forms of parasites to which an important part in nosology was to be attributed, on which occasion he invented and first used the term "mycosis," which has since been generally adopted. Brauell's papers on the bacterial parasite of anthrax, following up the researches of Davaine and Pollender, appeared in the eleventh and fourteenth volumes of the "Archiv," and were followed by numerous papers in that and other journals. Obermeier found the *spirochæte* in the blood of relapsing fever, in Virchow's hospital division, in 1873.

Virchow himself has said on this subject, in answer to an attack by his former pupil Klebs: "Vegetable and animal parasites are among the causes of disease. Their place is in etiology, and therefore it is easily conceived that, as Klebs expresses himself, they found no place in my cellular pathology. There it was not any more my domain to offer an extensive paper on parasites than it was to treat of traumatic injuries and corrosions. In my cellular pathology I meant to demonstrate the changes which take place in the elements of the

organism in the general forms of disease. Thus, I meant to build up a theory of the essentiality of disease. Specific causes were mentioned only as examples—for instance, intoxication ; and, though but briefly alluded to, parasites have not been entirely overlooked."

His attitude toward Darwinism has been likewise misapprehended. Far from being an opponent of Darwinism, he should be regarded as one of its forerunners, for, as early as 1849, in his "Movement in Favor of Unity in Scientific Medicine," he spoke of the origin of life as a mechanical necessity ; and in 1858, a year before the publication of Darwin's "Origin of Species," he pointed, in an oration which was afterward printed in 1862, with three other orations on "Life" and "Disease," to the changeability and transmutability of species as a necessary basis for the mechanical theory of life. But, when Haeckel insisted upon the inclusion of the theories of natural selection among the subjects to be taught in the public elementary schools, Virchow objected that only established facts and results, not theories, should be taught in the public schools.

To Haeckel's contradictions of religious faith Virchow is able to return a tacit answer, by adhering to what he wrote more than thirty years ago, that "faith does not admit of a scientific discussion, for science and faith exclude each other. Not to such an extent, however, that one of them renders the other an impossibility, but in such a way that, within the range of science, there is no place for faith ; and the latter can commence only where the former ends. It need not be denied that, if this boundary-line be respected, faith may have actual objects. It is not, therefore, the domain of science to attack faith or its objects ; but its duty is to mark and consolidate the present termination of knowledge."

Among the earlier papers written by Virchow and published in his first collections were some on different features and diseases of the skull and brain. These were followed by other cranial studies, and thus the physician was led to the study of anthropology, archæology, and paleontology. He was one of the founders of the German Archæological Society, which was organized at the meeting of the German naturalists at Innsprück in 1869, and he became the president of the society in 1870. He has also been the leader of the Berlin Anthropological Society since 1869, and has himself undertaken extensive and important researches. Having become engaged in a controversy with Quatrefages respecting the origin of the Prussian race (Quatrefages maintaining that it was of Finnic descent), he instituted those investigations, among the school-children of Germany, into the relative prevalence of blondes and brunettes, which have proved very interesting in their progress and results, and which have been taken up in other states. As a member of the Academy of Sciences, to which he was elected in 1873, he read important anthropological papers in 1875 and 1876 ; and in the latter year delivered an address at the meeting

of the German naturalists on the present position of anthropology, in which he maintained that that branch, although one of the youngest of the sciences, already occupied as advanced a position as many of the older branches of study. He opposed the idea that the people now lowest in development must necessarily fade away when they come into contact with civilization, and showed that it was contradicted by the history of the Europeans themselves. If the civilized people of the present day be considered as the product of a higher development, he said, we can not regard the possibility of such a development as a cause of the extinction of such people as are now on the same platform of culture which we ourselves once occupied. He took an active interest in the investigations of Dr. Schliemann in the Troad, and spent some time there, participating in the work, in 1879. He gave particular attention to the formations of the swamps in the neighborhood, and of the building-stones, and showed that they were all of fresh-water origin, thus conclusively putting to rest, it was held, the objections of those who, opposed to the view that Hissarlik represented the site of ancient Troy, that, at the time of the Trojan war, the place must have been covered by the sea, or too near it to permit the movements described in the Iliad. While here, he gave valuable medical aid to the people of the region.

Professor Virchow has labored actively for the spread of scientific knowledge among the people. He was for a long time a member of the body of instructors to the Berlin Workingmen's Union, and in that capacity published, in connection with Holtzendorff, a collection of popular scientific treatises.

The scientific side, although there is enough of it to fill up an ordinary human life, is only one side of Professor Virchow's career. His life is equally full on the political and practical side. Since 1859 he has been an alderman of the city of Berlin, and has in that capacity given conscientious attention to the details of the government and wants of the municipality. In direct reference to this office he has written many papers on subjects of hygiene, drainage, and sewerage, marked alike by scientific thoroughness and by adaptation to local wants. He was elected a member of the Prussian Chamber of Deputies in 1862, having the choice between the seats for three constituencies offered to him, and has served in that body with distinction ever since. He at once took the lead among those who opposed the arbitrary measures of Bismarck and his despotic assumptions; and has continued one of the most vigorous and formidable antagonists of that minister. In January, 1863, he proposed and secured the acceptance of an address accusing the ministers of having violated the constitution. In 1865 his opposition was so energetic that there was talk of Herr Bismarck's challenging him to a duel. He did not, however, assume an extreme democratic position, but accepted the constitution with the reservation of the right of protest against objectionable measures which might be pro-

posed under it. The events of 1866 cast his party into the shade for a time, but he gradually resumed, in the enlarged Prussia, his opposition to the measures of military rule and centralization. In 1869 he made a proposition in favor of an international disarmament, which was of course rejected. He was elected a deputy to the Diet of the North-German Confederation, and afterward of the German Empire, but declined both calls on account of his objections to the constitutionality of those political creations. He, however, consented to enter the Reichstag in 1880, as a member from one of the conscriptions of Berlin. He was the author of the expression "*Kulturkampf*"—battle for culture—in connection with the controversy with the papal power, which was so long a political watchword in Germany. His political work, well performed as it was, was never allowed to interfere with his scientific pursuits, which he regarded as his proper and serious labor, but it often appeared to him, he says, "to be rather a recreation than otherwise." In 1872 he replied with a refusal to an invitation by a German society to withdraw from the French scientific societies of which he was a member, declaring that a rupture of the scientific relations between the two countries would be contrary to the interests of civilization, of science, and of humanity. He was a member of the Sanitary Associations of Berlin during the wars of 1866 and 1870, organized the first Prussian sanitary train, and had a part in the organization of several military and other hospitals. He is the author of new laws in reference to the contagious diseases of animals and to fisheries. Last year he was one of the speakers at a public meeting to do honor to the memory of our murdered President, James A. Garfield.

Professor Virchow's published works are numerous. A large proportion of them consist of special papers on medical subjects, many of which have appeared from time to time in the "Archiv," or are included in the two collections of "Contributions to Scientific Medicine" (1857) and "Treatises connected with State Medicine and Epidemiology" (1879). Important studies of prevalent disorders and epidemics are embodied in his report on the famine in the Spessart (Bavaria), the typhoid fever in Silesia, and leprous affections in Norway, and in his essays on cholera and trichinosis. His "Cellular Pathology," which forms the first volume of his "Lectures on Pathology," in four volumes, has been translated into several languages. "The Pathology of Tumors" (three volumes, 1863–1867) is the most exhaustive and comprehensive work on that subject. Works of a more general character are "Goethe as a Naturalist" (1861), "National Development and the Importance of the Natural Sciences" (1865), "The Education of Women for their Vocation" (1865), "The Problems of the Natural Sciences in the New National Life of Germany" (1871), and "The Liberty of Science in the Modern State" (1877).

EDITOR'S TABLE.

MATTHEW ARNOLD ON LITERATURE AND SCIENCE.

IT was hardly to be supposed that Professor Huxley's address at the opening of Sir Josiah Mason's College would be left without some attempt at a formal answer. The bare establishment of a collegiate institution, from which "mere literary instruction" was excluded, was not in itself very important, as it is not expected that mechanical, technical, and industrial schools will give much attention to literature at any rate. But when literary education, as a method of culture, was attacked as narrow and inadequate, and another method more liberal, more efficient, based upon science, and claiming superiority upon that ground, was forcibly presented so as to elicit extensive assent, the challenge to the devotees of literary cultivation could not be passed by.

In this crisis, Mr. Matthew Arnold comes forward as the champion of literature. His position was recognized by Professor Huxley as among the foremost in English literature, and he quoted from him the positions to be contested. Mr. Arnold was therefore in a sense called out, and he has made his response in an address before the Cambridge University, which we reprint from the "Fortnightly Review." We are interested in seeing how an eminent literary man deals with the two methods of study, and from this point of view the discussion will justify some comment.

Mr. Arnold first deplores what he considers the crusade of science against literature; and then tries to make out that, properly considered, there is no ground of controversy. But, because he does not or will not see the other side, is not a sufficient reason for denying its existence. There is undoubtedly a broad issue at the present time between literature and science, as distinctive methods of mental culture. The literary method grew up and was carried to great perfection by the creation of the masterpieces of literary art long before science appeared. That method has continued to the present time as a separate influence, and with a distinctive ideal in the traditional systems of education. It is undeniable that, as our colleges are constituted, a liberal, classical, literary education can be obtained with but very little knowledge of science, and it is notorious that great multitudes acquire a comprehensive literary culture while remaining as ignorant of the sciences as they would have been in the scholastic ages. If there is to be any comparison of methods, their characteristics must be limited and defined, and certainly there is no difficulty in distinguishing the quality of literary cultivation.

Mr. Arnold had said, "In our culture the aim being to know ourselves and the world, we have, as the means to this end, to know the best that has been thought and said in the world." It is fair to infer that the word "best" is here to be interpreted by the literary standard—not by *everything* that has been thought and said, but by the "best," that is the choicest, the finest, the most excellent, as found in the supreme literary performances of both the ancient and modern mind. That this was Mr. Arnold's meaning is evident from another passage quoted by Professor Huxley. He says: "Europe is to be regarded as now being, for intellectual and spiritual purposes, one

great confederation bound to a joint action and working to a common result; and whose members have for their common outfit a knowledge of Greek, Roman, and Eastern antiquity and of one another. Special local and temporary advantages being put out of account, that modern nation will in the intellectual and spiritual sphere make most progress which most thoroughly carries out this programme."

From this Professor Huxley dissents and declares that he finds himself "wholly unable to admit that either nations or individuals will really advance, if their common outfit draws nothing from the stores of physical science. An army without weapons of precision, and with no particular base of operations, might more hopefully enter upon a campaign on the Rhine, than a man devoid of knowledge of what physical science has done in the last century upon a criticism of life."

To this Mr. Arnold replies by flatly repudiating the accepted interpretation of the scope of literary culture; he would even so widen it as to include all science. He says: "When I speak of knowing Greek and Roman antiquity as a help to knowing ourselves and the world, I mean more than a knowledge of so much vocabulary, so much grammar, so many portions of authors in the Greek and Latin languages. I mean knowing the Greeks and Romans, and their life and genius, and what they were and did in the world. . . . By knowing modern nations, I mean not merely knowing their *belles-lettres*, but knowing also what has been done by such men as Copernicus, Galileo, Newton, Darwin." And further, "in the best that has been thought and said in the world, I certainly include what in modern times has been thought and said by the great observers and knowers of nature." That is, science disappears as a separate intellectual interest by its complete absorption in literature: neat but unsatisfactory.

Mr. Arnold is quite aware of his disadvantage in dealing with Professor Huxley, who is strong in both literature and science, and he repeatedly refers to the slenderness and deficiency of his own scientific attainments. But, had he been more perfectly aware of them, he would hardly have ventured upon this mode of escaping from the issues that have arisen between literary and scientific culture. Had he better understood what is meant by the scientific method, he would not have tried to stretch the literary method so as to embrace and incorporate it.

Without asserting that the relations of these two methods of culture are essentially antagonistic, it remains true that they are so profoundly different that they are not to be confounded or identified. By literature we mean, and rightly mean, the study of books of language, of the arts of expression and criticism, and familiarity with the most perfect written productions, as such, whether in prose or poetry, that have been produced in all time. And literature as a method of mental culture is simply a training in these various acquisitions and exercises.

But the scientific method which has arisen in modern times began in an open and declared revolt against this mode of occupying the human mind. It involved new objects, new procedures, and new disciplines of thought. Seeing that the mind for ages had been arrested at verbal studies, and had failed in the production of solid knowledge, men began to demand an advance to the actual study of things. This is the essence of the scientific method, and it has achieved its great results only by repudiating the old literary occupations, and proceeding directly to the research of nature. The sciences have arisen, knowledge has been extended, power over nature conferred, and a new civilization created only by concentrating thought upon the realities of experience instead of studying

nature, life, and man, as they are represented in literature. To incorporate the scientific method with the method of literature is impossible; to subordinate it to that method is to destroy it. That which is obtained from books alone, without an acquaintance with phenomena, is not true science but sham science. Scientific culture is a training and a grounding in the scientific method, a mental habit of observing, analyzing, and comparing the actual facts, and the advantages of this method can only be gained by a distinctly recognized, independent, and systematic culture.

How different and how contrasted the literary and scientific methods really are, becomes again apparent when we observe the feelings to which they respectively give rise. Mr. Arnold continually refers in his article to two elements of human nature to be satisfied by culture, the sense for beauty and the sense for conduct; but he nowhere speaks of the sense for truth, and this, obviously because truth, as an object of feeling, does not enter into the literary ideal. It was, in fact, because literature as a method had never cared for truth, and had no interest in the search for it, that the need for science arose to repair the omission; and science has only advanced as the feeling for truth has been developed and deepened. To the man of letters, devoted to the beautiful, the fine in art, and the pleasing in life, the scientific passion for truth is unintelligible and very naturally repugnant. The annals of literature are full of the aversion of its cultivators to science and all that belongs to it. The last example is given by Mr. Boyesen, who talked much with the poet Longfellow, and has printed some of his chronicles in the "Christian Union." He says of Mr. Longfellow: "The scientific questions which agitate the intellectual atmosphere of the century also left him cold; and if they were touched upon in his presence he soon showed by the vagueness of his answers that the topic was not congenial to him. His thoughts moved in a purely literary sphere, and I believe I do him no injustice if I say that life interested him primarily in its relation to literature. He was of opinion that Goethe made a mistake in devoting so much of his energy to scientific pursuits, and that his later works (particularly 'Elective Affinities' and his second part of 'Faust') were much injured by the influence of his scientific theories." This dislike of science means nothing more than intense devotion to an ideal that is foreign to science. But, on the other hand, the scientific ideal gives rise to emotions of its own, of equal if not even greater intensity. The history of science has proved that the love of truth is one of the strongest passions of human nature. It has abundantly proved that men will forego all the lower and common enjoyments of life, when that becomes necessary, to promote the attainment of truth. So powerful may this feeling become that the customary selfish pleasures and ambitions of men seem trivial and contemptible in comparison; and who will say that this love of truth, which is the inspiration of the scientific method, is not the noblest impulse that can animate the mind of man?

But, when half through his address, Mr. Arnold *does* find an issue between literature and science. He says: "But it is proposed to make the training in natural science the main part of education, for the great majority of mankind at any rate. And here, I confess, I part company with the friends of physical science, with whom, up to this point, I have been agreeing. . . . At present it seems to me that those who are for giving to natural knowledge, as they call it, the chief place in the education of the majority of mankind, leave one important thing out of their account, the constitution of human nature." Knowledge, he admits, is interesting, and much of it important, but it

comes in fragments, and Mr. Arnold thinks there is something in human nature that desires "to relate these pieces of knowledge to our sense for conduct, to our sense for beauty." And again: "We feel, as we go on learning and knowing, the vast majority of mankind feel, the need of relating what we have learned and known to the sense we have in us for conduct, to the sense we have in us for beauty."

But, if Mr. Arnold had gone on to say and to the sense we have in us for truth, he would have struck an element in human nature more potent than any other for bringing the disjointed fragments of knowledge into harmony and unity. It is that use of the faculties which has led to the creation of knowledge which must be trusted to bring it into the most perfect relations. Mr. Arnold parts company with science in the name of the demands of human nature, but our first demand concerning human nature is that it shall be understood. Literature never explained it—could not explain it, because the study of principles and laws, and the decomposition of complex things into their elements, and finding out the truth, were not embraced in its method. In parting company with the students of science on such grounds, Mr. Arnold virtually concedes that they have a method of their own, though a method which he can not approve. He raises the issue of superiority, but he does not settle it. He expatiates on the utilities of literature, but he offers no proof that its past ascendency is still justified, because he seems to have no true or adequate conception of the claims of the scientific method. We point, on the other hand, to what science has done for mankind as evidence of the greater things it may yet be expected to do, and to the soundness, comprehensiveness, and thoroughness of the training which it enforces in proof of its superiority in the preparation of men for the intelligent discharge of their duties to themselves, to their families, to society, and to humanity.

THE MONTREAL SCIENTIFIC MEETING.

THE American Association for the Advancement of Science held its annual meeting this year in Montreal, under the able presidency of Dr. J. W. Dawson, Principal of McGill College, and eminent as a geologist and paleontologist. The gathering was large, the various sections were strongly represented, and the labors of the scientific body every way successful. A large number of papers were registered, many of them important, and they were got well through with, notwithstanding the tendency to consume time in their discussion.

The American Association met at Montreal twenty-five years ago, and had an excellent convention at that time. But the changes of a quarter of a century have been marked. Strong men have passed away, and new men of no less promise have taken their places. Old scientific questions have taken on new aspects, and new questions have come to the front. The city whose hospitalities were so liberal in 1857 has become a much larger and more beautiful city in the interval, and the generous reception given to the large body of strangers shows that the prosperity of Montreal has not been at the expense of its liberal spirit and hospitable feeling. We print the excellent address of Professor Brush, given upon his retirement from the presidency of the Association. His theme was well chosen, and, if less ambitious than those frequently taken on these occasions, it was none the less instructive and important. Mineralogy is not one of the show sciences, that attract much popular attention, but it is a science of profound interest and great economic importance, and Professor Brush could not have chosen better than to give us this admirable account of its American progress.

LITERARY NOTICES.

NATURAL RELIGION. By the author of "Ecce Homo." Boston: Roberts Brothers. Pp. 251. Price, $1.25.

THIS little book, by Professor J. R. Seeley, of the Cambridge University (England), deserves the most serious consideration on the part of all who care for the higher questions of modern controversy. Some of its chapters first appeared in "Macmillan's Magazine," and were reprinted in the "Monthly," while the author's name was unknown. But they were evidently by a man of power, insight, independence, and great catholicity of spirit; and they handled the exciting and even the exasperating questions of the time, not only with a striking originality, but with a forecast of new agreements most encouraging to all who are concerned about the religious progress of mankind. The great distinctions and differences over which people are quarreling and disputing in the religious and anti-religious world Professor Seeley does not regard as finalities. Under severe critical examination, they diminish and are found to have no justification in the truth of things. The work is one of the most composing and harmonizing that has appeared in this age. That the writer deals with the most radical problems of religious thought is shown in the titles of his chapters. In Part I the subjects treated are: (1) "God in Nature," (2) "The Abuse of the Word Atheism," (3) The words "Theology and Religion," (4) "The Three Kinds of Religion," (5) "Natural Religion in Practice," while in Part II the questions discussed are: (1) "Religion and the World," (2) "Religion and Culture," (3) "Natural Christianity," (4) "Natural Religion and the State," (5) "Natural Religion and the Church."

Holding this book to be of unusual importance, we are desirous of conveying to our readers a fuller account of it than we can prepare, or are in the habit of allowing in these pages, and we therefore reprint the review of it which appeared in the London "Athenæum" of July 29th:

If it be the function of genius to interpret the age to itself, this is a work of genius. It gives articulate expression to the higher strivings of the time. It puts plainly the problem of these latter days, and so far contributes to its solution; a positive solution it scarcely claims to supply. No such important contribution to the question of the time has been published in England since the appearance, in 1866, of "Ecce Homo." That the same man should have written both books, that none but himself can be his parallel, argues a unique order of mind. He is a teacher whose words it is well to listen to. His words are wise but sad; it has not been given him to fire them with faith, but only to light them with reason. His readers may at least thank him for the intellectual illumination, if they can not owe him gratitude for any added fervor.

The object of this book, one might say with logical precision, is to extend the connotation of the term "religion." It groups together all the great idealisms—art, science, culture—and claims that these are natural religion. Thus, according to this author, everything that takes us beyond and above our selfish aims is religion. The opposition between science and theology becomes vain and of no effect: both are forms of religion. The indifference of art for the conventions is but another form of the struggle against worldliness, and here again art and religion join hands. "Wer Wissenschaft und Kunst besitzt," said Goethe, and our author repeats the saying with approval, "hat auch Religion." Professor Huxley and Mr. Burne Jones will be somewhat surprised to find themselves regarded as great lights in the religious world. The old triad of ideals—the good, the true, and the beautiful—are classed by this observer under the one genus of religion.

Turning to the practical side of the book, we have the demand that the Church should learn the error of her ways in not recognizing her two companions in the struggle against the lower life, and should renounce the parts of her doctrine that conflict with their ideals. The idea of development must be applied to religion as to everything else, and the conception of prophecy be revived in the modern form of a philosophy of history. Let the cultured classes teach culture, which is religion, to the lower classes, who will otherwise lapse into Nihilism; and let the cultured nations of Christendom spread the light of religion till one great bond of civilization span the earth. Above all, if we wish to master the art of life, let us study the experiments that have been made by time in the field of history, and learn the lessons of "philosophy teaching by example."

Such, in main outline, are the theorems and problems of this brilliant book. The boldness of the *eirenicon* can not but strike every reader; but the age is bold in these matters, and this quality is only another mark of the timeliness of the book. In looking at its practicability, however, a critic has to remember that, while it takes two parties to make a quarrel, it also requires two to patch one up. Our author is wanting in one of the qualities of the peace-maker that are almost necessary for the due performance of his office: he lacks sympathy with one of the sides. He is entirely on the side opposed

to the angels, and assumes too confidently that supernatural religion is spiritually defunct, and its advocates ready to own their inefficiency. He is candid and clear-sighted, and sees distinctly that what he calls religion will be called in turn pantheism and paganism by "religious" people. But he trusts too readily that they will be convinced that, in using these names, they are miscalling persons of practically the same creed as themselves. He greatly underrates, one can not help thinking, the power that such conceptions as miracles, and heaven and hell, exert upon minds that have once firmly grasped them. At times this miscalculation leads him to adopt a tone toward the adherents of supernatural religion which is, to say the least of it, by no means conciliatory. Take, for instance, the following sentence:

"The Eternal and the Infinite and the All-embracing has been represented as the head of the clerical interest, as a sort of clergyman, as a sort of schoolmaster, as a sort of philanthropist."

The reminiscence of Mr. Matthew Arnold might remind our author that Mr. Arnold has scarcely reconciled Dissent, however he may have undermined it. In short, our author appears to agree with Goethe, when he cynically concludes the above-quoted epigram:

"Wer Wissenchaft und Kunst nicht besitzt
Der habe Religion."

Further, our author is scarcely so successful in showing the fundamental identity of art and religion as of science and religion. When touching on the latter point he draws some instructive and novel analogies between the creed of science and the faith of the Old Testament:

"I say that man believes in a God who feels himself in the presence of a Power which is not himself, and is immeasurably above himself; a Power in the contemplation of which he is absorbed, in the knowledge of which he finds safety and happiness."

"But now, either under the name of God, or under that of Nature, or under that of Science, or under that of Law, the conception works freshly and powerfully in a multitude of minds. It is an idea, indeed, that causes much unhappiness, much depression. Men now reason with God as Job did, or feel crushed before him as Moses, or wrestle with him as Jacob, or blaspheme him; they do not so easily attain the Christian hope."

"We have spoken of science as replacing miracle; prophecy it does not so much replace as restore. As it grasps human affairs with more confidence, it begins to unravel the past, and with the past the future. It shows the significance of each new social or political phase as the Hebrew prophets studied to do."

These quotations may serve to illustrate the author's main contentions as to the relation of science and religion. But it is more difficult to explain his views as to the connection of the artistic and religious ideals. He points out the great influence of the poet on the higher life of the time, reviving Mr. Arnold's "criticism of life" view; and he recognizes the ideal tendencies of the Antinomianism that is generally associated with artistic impulses. But he almost invariably regards art as solely dealing with beautiful objects of sight, and thus bringing it into contact with the scientific observation of nature. We have throughout observed not one word devoted to music, yet there are thousands nowadays with whom the cultus of rhythmic and harmonic sounds has usurped the place of almost all other worship, and a work on natural religion should have taken notice of their case. And on art in general, barring a few excellent pages on Goethe and Wordsworth, little is said that justifies the position given her alongside of science and religion. That position may be deserved; but the arguments brought forward in this book do not show adequate appreciation of the artistic mind.

Apart from this lack of sympathy with the orthodox schools of religious opinion, and an inadequate estimate of the artistic ideal, it is possible to find fault with other lines of the argument. There is, perhaps, a certain amount of professional exaggeration in the estimate formed of the historian's office. It is, to say the least, paradoxical to assert, "It is not exclusively, but only *par excellence*, that religion is directed toward God." It is obscuring a fundamental distinction to include, as our author often does, humanity in nature. The argument from Mohammedanism, that there may be a religion without miracles (p. 192), may be turned another way, when we reflect how inevitably the earliest traditions introduced miraculous events into the life of the Prophet. And interesting as is the attempt to widen the meaning of religion, it too often results in mere paradox, and manages only to evade difficulties by denying that they exist. Still the aim of the author, which is to point out the large amount of agreement among conflicting parties, is perfectly legitimate, and permits a certain exaggeration in looking only at common qualities, and neglecting divergencies.

Turning to the more pleasant and more profitable task of pointing out the many novel ideas and brilliant thoughts contained in this book, one has first to notice the power of acute social diagnosis that is throughout displayed. Take, for instance, the following *résumé* of the scientific temper:

"Instead of that painful conflict with temptation which moralists describe, there may be an almost unbroken peace arising from the absence of temptation; instead of the gradual formation of virtuous habits, there may be the gradual disuse of all habits except the habit of thought and study; there may be perpetual self-absorption, without what is commonly called selfishness, total disregard of other people, together with an unceasing labor for the human race. A life, in short, like that of the vestal, 'the world forgetting, by the world forgot,' yet without any love or heavenly communion."

Or, again, take the few but weighty words dealing with Nihilism; or the account of the

epidemic character of crime; or the remarks on the rise of self-distrust consequent on the decline of authority; or the view that the modern schoolmaster is a kind of professional parent. And joined to this power of observation is found the power of expressing its results in short, pithy phrases or sentences that stick in the memory. "Life is interesting if not happy" is a whole answer to Mr. Mallock. "Is life but a livelihood?" is a home-thrust at a certain school of politicians. "Worship is habitual admiration" is not likely to be bettered for some time as a working definition.

Nowadays one is not allowed to call a book brilliant unless it says some witty and therefore spiteful things. Even these are not wanting in the pages of "Natural Religion." Let us cull a few that display this quality:

"If you want to see the true white-heat of controversial passion—if you want to see men fling away the very thought of reconciliation, and close in internecine conflict, you should look at controversialists who *do not differ at all*, but who have adopted different words to express the same opinion."

"What should we think, then, if its name and its glories formed the staple of our religious worship, if our church-goers sang, 'Oh, pray for the peace of England—they shall prosper that love thee'?"

"'Erudition' and 'philosophy' are terms of contempt in their mouths. They denounce the former as a busy idleness, and the latter as a sham wisdom, consisting mainly of empty words, and offering solutions either imaginary or unintelligible of problems which are either imaginary or unintelligible themselves."

But of far more importance than these isolated instances of acuteness of thought or phrase are the many new positions taken up in this book. The distinction between theology and religion has never been brought so clearly into connection with the difference between scientific and imaginative knowledge. The three different phases of atheism—by which term is meant by this author want of adaptation to the environment—are excellently discriminated.

It may cause some surprise, but can not fail to cause as much enlightenment, to find our author, most modern of the moderns as he is, advocating the closest possible union between Church and state, and defending his position by all the wealth of his historical knowledge. But has ever the modern temper been hit off more exactly than in the following passage?—

"Another maxim has to be learned in time, that some things are impossible, and to master this is to enter upon the manhood of the higher life. But it ought not to be mastered as a mere depressing negation, but rather as a new religion. The law that is independent of us, and that conditions all our activity, is not to be reluctantly acknowledged, but studied with absorbing delight and awe. At the moment when our own self-consciousness is liveliest, when our own beliefs, hopes, and purposes are most precious to us, we are to acknowledge that the universe is greater than ourselves, and that our wills are weak compared with the law that governs it, and our purposes futile except so far as they are in agreement with that law."

But enough. We have given the main argument of the book, and selected some of its details for discussion or for admiration. It remains to discuss its probable effect on the two parties between whom, in a measure, it attempts to effect a reconciliation. It has already been pointed out that the religious world will regard its religion as having been misunderstood, and not sympathized with; and this complaint will be just. It is natural, at this point, to compare the somewhat similar attempts of Mr. Matthew Arnold in this direction; and it must be owned that, with regard to knowledge of and sympathy with orthodox belief, the whilom Oxford professor is the superior of his Cambridge rival, if we may venture so to term the author of "Ecce Homo." Mr. Matthew Arnold was bent on battling with religious Philistinism, and did not disdain to deal it some heavy and rather unfair blows, chiefly by way of irony. Our author, on the contrary, cares more to expound the position of *nous autres*, and has, for the first time, given an adequate exposition of the creed of culture. "Religion," he says, "has been revived under the artificial name of culture"; and, again, "The momentary evanescence of the Church in modern life is only caused by the decay of one sort of Church coinciding in time with the infancy of another." In thus boldly pointing out that the spiritual currents now flow in other channels than those that are technically called religious, the book says what many have been feeling. It must necessarily give courage to the Antinomians, and give, for the first time, a true sense of their position to the followers of ancient lines of thought. That the followers of culture will consent to call their ideal by the name of religion, and that the believers of religion in its old sense will grant that name, full of the most sacred associations, to the pursuit of truth and of beauty, are very doubtful propositions. So far, therefore, as our author seriously aims at these innovations his efforts appear doomed to failure. No *eirenicon* can be effected between two opposing schools by inducing them to adopt the same name on their banners. It is by bringing into full consciousness the thoughts and feelings of modern men that this book will exercise its chief influence. It will enable the adherents of the old and of the new faith to know for what the strife is being carried on. And it shows how fast and far the world has been drifting since 1866 to reflect that this book takes the place of an exposition of "Christ's theology" promised in the preface of "Ecce Homo." But the second or "practical" part of the book is not practical in any sense that leads to action. It merely shows that the natural religion which is his theme is really in action among us in influencing men's lives. It may set men thinking, it can not lead them to act. Meanwhile, let us close this notice of a book which we assume will be read by most thinking Englishmen with a

final quotation, which shows at once the power and the weakness of the writer, his clear vision and his depressing tone:

"For Art and Science are not of the world, though the world may corrupt them; they have the nature of religion. When, therefore, we see them shaking off the fetters of the reigning religion, we may be anxious, but we are not to call this an outbreak of secularity; it is the appearance of new forms of religion, which, if they threaten orthodoxy, threaten secularity quite as much. Now, secularity is the English vice, and we may rejoice to see it attacked. It ought to be the beginning of a new life for England that the heavy materialism which has so long weighed upon her is shaken at last. We have been, perhaps, little aware of it, as one is usually little aware of the atmosphere one has long breathed. We have been aware only of an energetic industrialism. We have been proud of our national 'self-help,' of our industry, and solvency, and have taken as but the due reward of these virtues our good fortune in politics and colonization. We have even framed for ourselves a sort of Deuteronomic religion which is a great comfort to us; it teaches that because we are honest and peaceable and industrious, therefore our Jehovah gives us wealth in abundance, and our exports and imports swell, and our debt diminishes, and our emigrants people half the globe."

ERNESTINE. A Novel. By WILHELMINE VON HILLERN, author of "The Hour will Come," etc. From the German by S. BARING-GOULD. In two vols. New York: William S. Gottsberger. Pp. 711. Price, $1.50.

ERNESTINE first appears before the reader as a little, much-abused, ill-tempered girl, about ten years old, who was neglected in everything except her schooling. When grown up, she thus describes herself: "From earliest childhood—at a time when most are rocked in the arms of love—are laid to sleep in the lap of love—I was trampled on, kicked about, almost tortured to death, because I was a girl. Every anguish-cry of my breast, every thought of my soul, every feeling of my young heart, was gathered into this one question, 'Why, why must I expiate what is no fault of mine—that I am not a boy?' And, in every wound that was dealt me, the seed of revenge was strewn—the seed of revenge for my own wrongs and those of my sex—the seed of ambition to do all that can be achieved by that sex whose superiority was so insultingly, so brutally paraded before me. It ripened quickly in the glow of indignation I felt at the injustice my sex is forced to endure, the difficulties which were opposed to its endeavors to rise above vulgar routine. It grew with me; it became mighty; it ramified through my whole mental life, like the veins and nerves of my body." When her application to attend the lectures and to be admitted to the dissecting-tables of the university was rejected, she declared to the committee that "the great struggle for the emancipation of woman can only be fought out to a definite conclusion on the comparative anatomy of the brain. . . . If, in some less scrupulous university, I be admitted to the dissecting-tables, and allowed the necessary anatomical and physiological studies, my time and energies will be given up to the solution of this question." But unceasing study undermined her health, and after a painful and involved experience the anti-social feelings that had been fostered by her abnormal childhood and youth gave way, and she became an affectionate wife and mother.

As a novel the book is engrossing and satisfactory, and, as a German contribution to the discussion of "The woman question," it is very interesting. The implication would seem to be that the usual course of domestic and social life in Germany does not favor the discontent of woman with her woman's destiny. It is under most exceptional circumstances that Ernestine is developed, and whenever she comes in contact with German society she is rebuked on all sides. It is the impression produced upon a very high-minded and accomplished young *savant* by her wonderful spiritual beauty, her purity of purpose, and earnestness of character that leads to her disenchantment. She is, however, allowed a little more time for a radical change of character than is accorded in most novels. But, as the author is dealing with people who are deeply versed in medical science and all modern research, this much was not unreasonably to be expected.

If Miss Von Hillern had been writing of woman's position in a novel of American life, her problem would have been different. She would find her discontented, ambitious, over-intellectual girls everywhere; which, of course, implies a state of society that fosters their production. She would find them both welcomed and influential in society, and, if not considered the most eligible can-

didates for matrimony, it matters very little to them. There is scope enough in this country for independent careers, and many of our "smart" girls fancy that on the whole an independent career is more desirable than marriage with its inevitable subordination of the woman. Fairly to present this subject to the American mind requires a careful study of the influences at home, at school, and on all sides, that are acting upon the minds of our girls and modifying their tastes and feelings, and, also, of those deeper biological characteristics which must remain essentially the same from age to age. It must be shown that from the beginning woman has been, and to the end she must remain, an emotional rather than an intellectual being—that much transient mischief and no good can come from a disturbance of this normal balance of thought and feeling in the mind of woman. It is high time that somebody in this country, be it novelist or essayist, should bring forward this view of the subject of "woman's rights." For the assumption of the identity of the minds of men and women is wide-spread. Hence the demand for identical education, and the opening to women of all our halls of learning. The fact that the emotional nature of woman has precedence at the present time is regarded as a principal reason for the educational movement. It is no education, or wrong education, we are told, that has deformed her true nature, and that her mind may assume right proportions she is called upon to cultivate intellect as a means of suppressing emotion.

This is precisely what Miss Von Hillern's heroine had striven all her life to do, and she fancied at one time that she had gained the victory for intellect. But all her striving comes to nothing. At last we find her exclaiming: "What are learning and fame, what the pride of position, compared with the happiness of this moment? Away with them all! my choice is made, Johannes," and she sank upon his breast. And this, too, when the last words said to her by her lover were these: "True humility will teach you to yield your fate unquestioningly to the man who gives his life to you. Go from me and you may be great, but you can not be womanly, and what is such greatness attained at the cost of a heart? Give up the false pride that would seek fame beyond the bounds of a woman's sphere, and confess that there is nothing greater that you can do than to enrich and bless the man who loves you." But, in Germany, where all the forces of society conspired to Ernestine's defeat, our authoress had no difficult task in reaching this result. It is not so easy to imagine a discipline that would bring one of our learned girls to this humble pass.

The subject is one of profound importance, and we commend the work to thoughtful readers, as well as to those who read novels only for entertainment.

PRACTICAL MICROSCOPY. By GEORGE E. DAVIS, F. R. M. S., F. I. C., F. C. S., etc. Illustrated with 258 Woodcuts and a Colored Frontispiece. London: David Bogue. Pp. 335.

THE neatly printed and beautifully illustrated book before us is somewhat similar to Quekett's "Practical Treatise on the Use of the Microscope," but is a smaller and less costly book, and one that brings the subject down to the present time. The various parts of a microscope are briefly described from a practical stand point, no mathematical calculations being introduced, nor is any attempt made to explain the *theory* of the microscope, further than it is of practical value. Although intended for students and even beginners, some singular omissions occur, such as explanations of the oft-used term "air-angle," or of the principle of "immersion lenses." The various accessories of the microscope are fully illustrated and described. There is a chapter on the collection of objects, another on micro-dissections, also on section-cutting and microscopic measurements. One of the most valuable features of the book is its full and accurate directions for making photo-micrographs, with cuts of apparatus. Recipes are given for the developing and fixing solutions, the printing and toning baths, and other parts of the photographic operations are minutely described. The chapter on the polarizing microscope is more full than we usually meet with in books of this character. The micro-spectroscope, the most modern of all the adaptations of the microscope, here receives the

attention that so remarkable an instrument deserves. The staining and injecting of objects are as fully treated of as the size of the book would permit, and a colored frontispiece is introduced to show the effect of double-staining on wood-sections.

The author exhibits commendable fairness in his treatment of American microscopists, and of instruments made on this side of the water, especially the wide-angled objectives of Spencer, of Geneva, and Tolles, of Boston. He says: "It is only recently that American objectives of the widest aperture have found their way into the author's hands. Their definition is marvelous." Medium angles have been advised for students' use, because they can be employed without much previous knowledge or difficulty; but for all purposes of scientific investigation wide apertures give more satisfactory results.

Many of the illustrations have been photographed by the author from nature and then cut in wood. Some of these are very fine, as, for example, the sting and poison-bag of the bee and wasp, the digestive apparatus of the water-beetle and of the blow-fly, and various other natural objects.

The rapid strides that have recently been made in the manufacture of cheap and very good working microscopes have created a demand for works of this character, and Mr. Davis's book supplies a real want.

GUIDE TO THE FLORA OF WASHINGTON AND VICINITY. By LESTER F. WARD, A. M. Washington: Government Printing-Office. 1881. Pp. 264.

THIS recent publication of the Smithsonian Institution contains the scientific and common names of 1,384 plants found in the vicinity of the national capital, together with their time of flowering, and in many cases the localities where they may be sought for. Appended are a check-list and a map of the region for fifteen or twenty miles around the city of Washington. The labor of preparing a "flora" of even a limited space of country is much greater than might be supposed, and in the present case many able and active botanists have co-operated with the author, as well as many energetic amateurs. The appearance of this work recalls to mind a remark of the late Dr. John Torrey, that in his younger days he attempted to prepare a flora of the City Hall Park, New York. At that time there was neither post-office nor court-house there. Even in that small space he met with so many and such a rapidly increasing number of varieties and species that he was compelled to abandon the project. From its cosmopolitan nature New York naturally receives fresh additions to her flora annually from every quarter of the globe. Even in Washington there has been a considerable change in the flora since the "Prodromus" appeared half a century ago. Of the 860 distinct plants enumerated therein, the author has succeeded in identifying 708, while nearly as many more have been added. Although the primary aim of the author was to furnish a guide to botanists in exploring the locality, it will serve as an aid to beginners in practical botany elsewhere. An appendix is added, especially addressed to the latter class, and containing among other things suggestions regarding identification of plants, collection of plants, preservation of plants, making an herbarium, care of duplicates, exchanging specimens, etc. On the first of these points the author remarks that "a young botanist's struggles with botanical keys can only be sympathized with; they can scarcely be aided by any general directions, and there is no more effectual drill than the persevering effort to identify, by the aid of a key, a plant to which he has no clew. It should be the ambition of every such beginner to analyze in this manner all the plants of his local flora." The less help he receives the better, and, the more ignorant the beginner is at the outset, the better will be his ultimate acquaintance with botany if he perseveres in the work. In regard to localities the writer very appropriately remarks that "in many respects the botanist looks at the world from a point of view precisely the reverse of that of other people. Rich fields of corn are to him waste lands; cities are his abhorrence, and great open areas under high cultivation he calls 'poor country'; while on the other hand the impenetrable forest delights his gaze, the rocky cliff charms him, thin-soiled barrens, boggy fens, and irreclaimable swamps and morasses are for him the finest land in the State. He

takes no delight in the 'march of civilization,' the axe and the plow are to him symbols of barbarism, and the reclaiming of waste lands and opening up of his favorite haunts to cultivation he instinctively denounces as acts of vandalism." Yet we may add, the botanist himself is no vandal, but his humble labors do contribute to the onward march of civilization. The humblest flower or coarsest weed may contain lessons of wisdom the most profound, and botany is particularly adapted to combine science and culture.

We can not close our brief notice without a mention of his defense of the herbarium as an instrument of scientific culture. It is a collection of natural objects, scientifically classified and ever present for inspection; an herbarium is a library to be consulted, studied, and read. It is a library filled with volumes written by Nature, and which those who have learned the language of Nature can read and enjoy with a satisfaction as much keener than anything that man-made books can give as it is nearer to the source of all truth.

REMINISCENCES CHIEFLY OF ORIEL COLLEGE AND THE OXFORD MOVEMENT. By Rev. T. MOZELY, M. A., formerly Fellow of Oriel. In 2 vols. Boston: Houghton, Mifflin & Co. Pp. 900. Price, $3.

THESE volumes belong to a popular class of works, and have attracted a good deal of attention as being quite unique in their line. They are gossipy, sketchy, spicy, and readable, and, although dealing with characters that figured and events that occurred half a century ago, and across the ocean, they will be read with interest and by many with avidity in this country. The interest in Oxford University, as a great seat of learning, is not confined to England, and everybody has heard of the Oxford movement, an ecclesiastical fermentation in the university which greatly disturbed the English Church, and involved the secession of many of her theologians to the Church of Rome. The work is thus characterized by a writer in the "Quarterly Review":

"It is, in great measure, a gallery of portraits, vividly and even brilliantly sketched, of the remarkable body of men who were connected with Oriel College for about half a century of its most famous period. The book is a succession of short chapters, each about the length of a leading article, most of them depicting the appearance, the habits, the capacities, and characters of a number of men who, for two generations, have played a leading part in English thought and life. Nothing but intimate daily association could have enabled even a genius like that of Mr. Mozely to hit them off with such distinctness and accuracy. But he and they were, for the most part, fellows or gentlemen commoners, or undergraduates of the same college; even if of different colleges, they lived in the same university, under similar conditions. He saw them going out and coming in; he dined with them; spent the evenings with them; worked side by side with them; managed business with them for years. All their characteristic and tell-tale traits fell under his daily observation, and he came to know them as well as, or perhaps better than, himself. If we had no other occasion for welcoming this book, we could not but rejoice to have such a vivid picture of a kind of life which has played so large a part in English society, drawn at the very time and in the very college where, perhaps, it reached its culmination. Mr. Mozely depicts it, not only with very rare powers of observation and of description, but with the keen appreciation of sympathy and of close attachment. As we read his pages we live in the Oxford and the Oriel of his day; we follow all its social politics, slight as they may seem, with the interest of real human life; we discern how all the little details developed characters and determined careers, and see before us, in scores of instances, that constant action and reaction of individuals and circumstances out of which the drama of life is developed."

In a book of so many details, and relating mainly to distant personal experiences, we might naturally expect a good percentage of error, and our pages this month bear testimony to Mr. Mozely's fallibility in this respect. He was a pupil in Derby of Mr. George Spencer, father of Herbert Spencer, and some of his reminiscences of his early teacher have proved so misleading as to require particular correction.

THE STUDENTS' GUIDE IN QUANTITATIVE ANALYSIS. Intended as an Aid to the Study of Fresenius's System. By H. CARRINGTON BOLTON, Ph. D., Professor of Chemistry in Trinity College, Hartford, Connecticut. Illustrated. New York: John Wiley & Sons. Pp. 127. Price, $1.50.

THE little book before us is intended as a guide for the student at his desk rather than as a text-book for study; it may be called a *key* to the comprehensive work of the distinguished Fresenius. In the latter the *science* of quantitative analysis is exhaustively taught, but the young chemist is too often bewildered by the wealth of material therein presented. He can not see the forest for the trees. Professor Bolton has cut a path for him through the wilderness; he has selected those points which it is important for the student to see, and placed them prominently before him. This book seeks to teach the *art* of quantitative analysis, without, however, entirely neglecting the science that lies at its base. The author presents a course of thirty-six typical analyses, arranged progressively from the simplest to the most complex, in the order that they are taken up in chemical laboratories generally, in the Columbia School of Mines particularly. The first analysis is that of barium chloride; each step in the operation is given in detail, and when the student has faithfully repeated these operations he has learned how to estimate barium, chlorine, and water of crystallization, in almost any salt. Next follows magnesium sulphate, in which he determines magnesium, sulphuric acid, and water. A few other salts follow, and, when the student has become familiar with chemical operations, natural and technical products are given, such as coal, ores, alloys, and slag, closing with water, sugar, milk, and petroleum. The whole course of quantitative analysis, both volumetric and gravimetric, is herein described, and the student who has made the analyse swith care will certainly have attained a considerable skill in manipulation, and can scarcely fail of obtaining an insight into the underlying principles which would enable him to devise methods adapted to other cases not given in the book. To aid in this, every step in each analysis contains a reference to the chapter and section in "Fresenius," where the operation is described, or to other authorities, when, as in a few cases, others were made use of. For this reason we have called it a "key," or guide, to the study of Fresenius. The book is intended as an aid to the teachers of quantitative analysis, to spare them the necessity of explaining to each student all the details of each analysis, which, in our overcrowded laboratories, the teacher has no time to do. It is equally suitable for "self-instruction," and by its aid any young person, with a fair knowledge of general chemistry, can, by himself, go through a course of analysis, lasting say two years, that would fit him for a position in a commercial or technical laboratory. The work is similar to Woehler's "Mineral Analysis," but fuller in detail, newer in methods, and in every way better suited to the wants of the American student. To compare things in totally different spheres, we would say that it resembles the "South Kensington Cook-Book," and this is no small praise.

ASTRONOMY FOR SCHOOLS AND GENERAL READERS. By ISAAC SHARPLESS, Professor of Mathematics and Astronomy, Haverford College, and Professor G. M. PHILLIPS, Principal of State Normal School, Westchester, Pennsylvania. J. B. Lippincott & Co. Pp. 303. Price, $1.25.

THIS is a very judiciously prepared school-book, neatly printed and elegantly illustrated. The explanations are clear, and the subject-matter of exposition well chosen for popular purposes. It opens with a sketch of the history of astronomy as part of an introduction, which is followed by a general view of the heavens and some considerations of the usefulness of astronomy. The solar system is then taken up in Part I, and the sidereal system in Part II, while Part III is devoted to the properties of light and astronomical instruments. There are no questions to the volume, but pains are taken to give the proper pronunciation of terms, and there are brief notices of the eminent men who have contributed to the progress of astronomy. No one book can combine all excellences, but this may be commended as well adapted for general school use.

PUBLICATIONS RECEIVED.

Atlantis: The Antediluvian World. By Ignatius Donnelly. Illustrated. New York: Harper & Brothers. Pp. 490. $2.00.

Astronomy for Schools and General Readers. By Isaac Sharpless and Professor G. M. Phillips. Philadelphia: J. B. Lippincott & Co. Pp. 303. $1.25.

Cerebral Hyperæmia: Does it exist? By C. F. Buckley, B. A., M. D., formerly Superintendent of Haydock Lodge Asylum, England. New York: G. P. Putnam's Sons. Pp. 129.

A Guide to Collodio-Etching. By Benjamin Hartley. Illustrated by the Author. New York: The Industrial Publication Company. Pp. 48, with Seven Plates.

Social Equality. A Short Study in a Missing Science. By William Hurrell Mallock, author of "Is Life worth Living?" New York: G. P. Putnam's Sons. Pp. 212. $1.00.

A Dictionary of the Popular Names of Economic Plants. By John Smith, A. L. S., author of "Historia Filicum," "History of Bible Plants," etc. London: Macmillan & Co. Pp. 457. $3.50.

Light. A Course of Experimental Optics, chiefly with the Lantern. By Lewis Wright. With Illustrations. London: Macmillan & Co. Pp. 366. $2.

Memoir of Daniel Macmillan. By Thomas Hughes, Q. C., author of "Tom Brown's School-days at Rugby." London: Macmillan & Co. Pp. 308. $1.50.

Strength of Wrought-Iron Bridge Members. By S. W. Robinson, C. E. New York: D. Van Nostrand. Pp. 175. 50 cents.

Railroad Economics. By S. W. Robinson, C. E. New York: D. Van Nostrand. Pp. 131. 50 cents.

First Annual Report of the Board of Health of Detroit. July, 1882. Detroit: Post & Tribune Co., Printers. Pp. 270.

The New Botany. A Lecture on the Best Method of teaching the Science. By W. J. Beal, M. Sc., Ph. D. Second edition, revised. Philadelphia: C. H. Marot. Pp. 16. 25 cents.

Houghton Farm: Experiments with Indian Corn. 1830-1881. By Manley Miles, Director of Experiments, with a Summary of the Experiments with Wheat for Forty Years at Rothamsted. By J. B. Lawes, Bart., LL. D., F. R. S. Cambridge: Riverside Press. Pp. 75.

Hand-Book of the St. Nicholas Agassiz Association. By Harlan M. Ballard, Principal of Lenox Academy. Pittsfield, Massachusetts: Axtell & Pomeroy, Printers. Pp. v–85.

Proceedings of the Department of Superintendence of the National Education Association at its Meeting in Washington, March 21-23, 1882. Washington: Government Printing-Office. Pp. 112.

The Comparative Action of Sulphate of Daturia and of Sulphate of Hyoscyamia upon the Iris and Ciliary Muscles. By Charles A. Oliver, M. D., of Philadelphia. Pp. 7.

Map of Alaska and Adjoining Regions. Compiled by Ivan Petroff, Special Agent, Tenth Census. Washington. Large Sheet.

Report of T. B. Ferguson, a Commissioner of Fisheries of Maryland. January, 1881. Hagerstown, Maryland: Bell & Co., Printers. Pp. cxiv, 152, and 6, with Plates.

Proceedings of the Davenport Academy of Natural Sciences. Volume III. Part II. Davenport, Iowa: Published by the Academy. Pp. 193, with Five Plates.

A Synonymical Catalogue of the Described Tortricidæ of North America, north of Mexico. By C. H. Fernald, A. M., Professor of Natural History in the Maine State College. Pp. 72.

The Hyperbolic Curve and the Law of Progression of Rotating Bodies. Boston: A. Williams & Co. Pp. 16.

Annual Report upon the Surveys of Northern and Northwestern Lakes, in charge of Major C. B. Comstock. Washington: Government Printing-Office. Pp. 24.

Arak-el-Emir. A Quarterly, devoted to the Expression of Clear Investigative Thought, conducted by J. C. Lane. New York: Quarterly Publishing Company, 21 Park Place. Pp. 82. 75 cents. Subscription, $3 per annum.

Elements of Universology. By Stephen Pearl Andrews. New York: S. P. Lathrop & Co. Pp. 48. 15 cents.

Ideological Etymology. A New Method on the Study of Words. By Stephen Pearl Andrews. New York: S. P. Lathrop & Co. Pp. 32. 15 cents.

Three Reports on Nomenclature and Terminology. By W. H. Atkinson. Pp. 6, 12, and 6. 5 cents each.

POPULAR MISCELLANY.

The American Association.—The meeting of the American Association for the Advancement of Science, at Montreal, which closed August 30th, was, in every respect, one of the most successful meetings in the history of the society. The attendance—nine hundred and fifty members—was but little short of that registered at Boston two years ago, and constituted it one of the large meetings. Three hundred and twenty-five new members were elected, and more than two hundred and fifty papers were accepted. The meeting was opened on the 23d of August, with a brief address by the incoming President, Dr. Dawson, of Montreal, who spoke of his (a Canadian's) election to the presidency as significant of the society's extension over the continent, and its disregard of national boundary-lines. Dr. T. Sterry Hunt, who followed the president as the especial representative of the city of Montreal, also spoke of the expansion of the society, and expressed the hope that it might yet meet in the city of Mexico, as the French had already carried their "war of science" into Africa, at Algiers. The nine sections into which the Association is now divided were severally opened with addresses by their respective presidents. Professor Bolton, in the Chemical Section, spoke on "Chemical Literature"; Professor Harkness, in the Mathematical and Astronomical Section, on the transit of Venus. Professor Brush, the retiring President of the Association, gave as his official address the compre-

hensive review which we publish in the present number of "The Popular Science Monthly," of the "Progress of American Mineralogy." Dr. Asa Gray gave an address on the "History of the Study of the North American Flora," and expressed the hope that the work of examination and classification might be completed in his lifetime, if it could not all be guided by his hand. The other papers were too numerous to be even catalogued here. We mention only a few, which seem to be of general importance or interest. They are those of Professor Mason, unfolding a scheme of anthropology; of Dr. John Rae, of London, on "Arctic Explorations and Ethnology"; of Commander Bartlett, on "The Gulf Stream"; of Mr. Franklin B. Hough, on "Plantations of the Eucalyptus"; of the Rev. Dr. Houghton, of Dublin, embodying a new theory of the evolution of the planets; of Professor Cook, of New Jersey, on "Evidences of Coast Depression"; of H. Carvill Lewis, on "The Great Terminal Moraine across Pennsylvania"; of Professor Newberry, on "The History of Plant-Life in America"; of the Hon. Horatio Hale, of Clinton, Ontario, on "Indian Migrations as evidenced by their Language"; and of Mrs. Erminie Smith and Miss Alice C. Fletcher, on topics relating to Indian ethnology. Excursions were made to Quebec, Ottawa, and other places. Several visitors of distinction were present from abroad. Among them, besides those already named in connection with their papers, were Professor W. B. Carpenter, of London, who read a technical paper in the Microscopical Section; Dr. Valdemar Kovalevski, of Moscow; Dr. Koenig, of Paris; Mr. Fitzgerald, of Dublin; and D. Szabo, of Buda-Pesth, Hungary, who had a paper in the Chemical Section. A good financial exhibit was made, with the announcement of generous special gifts. A memorial to Professor Rogers was determined upon. The Association decided to hold its meeting for 1883 at Minneapolis, Minnesota. The following officers were chosen: President, Professor C. A. Young, of Princeton; vice-presidents of sections: Mathematics and Astronomy, W. A. Rogers, of Cambridge; Physics, H. A. Rowland, of Baltimore; Chemistry, E. W. Morley, of Cleveland; Mechanical Science, De Valson Wood, of Hoboken; Geology and Geography, C. H. Hitchcock, of Hanover; Biology, W. J. Beale, of Lansing; Histology and Microscopy, J. D. Cox, of Cincinnati; Anthropology, O. T. Mason, of Washington; Economical Science and Statistics, F. B. Hough, of Lowville. The purpose of the British Association to hold its meeting for 1884 in Montreal was announced.

Scientific Forestry.—There is no mystery in the scientific cultivation of forests, so far as concerns the tillage of the crop. All that is needed is to observe the action of nature in the forest, and follow it, or utilize it advantageously, when that can be done. The object of the cultivation should be to obtain the utmost possible advantage from the soil by keeping it always covered with a growth of trees; and, when the trees arrive at maturity, to remove them in such a manner that the smallest possible interruption may be caused to the productive work of nature. When the time has come for the removal of the timber, the ground should on no account be anywhere all cleared of trees at once; but a commencement should be made by felling a tree here and there, and so breaking the thick cover of the forest as to allow sufficient light and air to reach the ground, and cause the seed which has fallen to germinate. In this way about one fifth of the mature trees should be removed every five or six years, never by making large gaps in the cover, but taking a tree here and there, and always leaving the finest and most vigorous trees till the last, so that in about thirty years the whole of the old trees will be cleared off, and a new forest established in their place. Thus the seeding of the wood will be effected by the agency of the finest trees, which will be themselves all the while increasing in bulk, and the productive power of the soil will be utilized to the fullest possible amount. It is not only in the removal of the timber and the reproduction of the forest that we ought to study the action of nature, but it is equally necessary that we should do so in the felling for improving the growing crop, or, as it is commonly called, the thinnings. The competition between trees after they reach their full height, at half their full age, is for space to spread their heads;

and from this time, till they arrive at maturity, they go on always augmenting the diameter of their stems, but at the same time decreasing in number. It is calculated that, if sixteen hundred trees of four inches in diameter can stand and thrive on an acre of ground, there will not be more than four hundred of them when the trees have grown to eight inches, two hundred when they have reached twelve inches, and between one hundred and one hundred and forty when they have attained sixteen inches in diameter. Little is to be done in the earlier stages of a forest's growth except to keep the heads of the most valuable species from being overtopped by those which stand near them: and this can be done best, not by removing the others, but by cutting off or breaking the tops; for it is desirable at this stage, for the sake of the natural pruning, to have the trees growing as thickly together as possible. At a later stage, thinnings can be judiciously arranged so as to pass through the entire forest at intervals of from ten to fifteen years, enabling the whole area to be operated on in turn. In executing these, the most difficult of all forest operations, it will be well to remember that the object is to give room to the heads of the trees, and not to their stems; for the stems will never be too close together as long as the heads have room properly to develop themselves. The favoring of the most promising trees, and the removal of the weaker ones, together with the preservation of continuous shade to the surface of the ground, while all the trees have sufficient room to grow, should be the particular ends aimed at.

A New Plan for Armored Vessels.—The Naval Committee of the United States House of Representatives has given favorable consideration to a new plan for building armored vessels which has been devised by a retired invalid engineer. The principal armorial application consists of a submerged "turtle-back," about four inches thick, and extending from side to side and from stem to stern of the vessel and below the water-line, so arranged that an enemy's shot from any direction can hit it only at a deflecting angle, so as to be thrown off rather than go through. The sides of the vessel above the turtle-back are filled in with cotton or cork, in which a breach made by the passage of a ball will be self-closed by the elastic action of the substance. They may, moreover, be shot to pieces without destroying the buoyant power of the ship. The guns are mounted upon heavy, impenetrable, centrally arranged, cylindrical armor, which extends to the bottom of the ship, and is there seated on an hydraulic cushion. The breech of the gun is also inclosed in an oval armor, so arranged as to deflect a ball, striking it from any point, in a harmless direction. The gun is operated by an hydraulic loading apparatus, which is worked by one gunner, and hydraulic buffers are provided to take up the recoil.

The Timber-Line of Mountains.—Mr. Henry Gannett, noticing, in "The American Journal of Science," Dr. Rothrock's statement that, as a whole, there is little or no increase in the altitude of the timber-line toward the equator in the Western hemisphere, south of the forty-first parallel of north latitude, observes that the height of the timber-line is purely a question of temperature, and that that is a function of the latitude, the elevation, and the mass, of the country in the neighborhood. A great mass of country, if raised to a considerable height above the sea, carries with it the isothermals. Therefore, in considering the height of the timber-line, "we must regard the mountain-ranges in connection with the plateaus on which they stand, their latitudes, heights, and masses, or what, in a measure, sums up these three, their temperatures, as it is by these that its height is determined." The actual elevation above sea-level of the timber-line in the Cordilleras of North America ranges from six or seven to twelve thousand feet. It is lowest in the Coast and Cascade Ranges of Washington Territory, and rises as we go southward through Oregon and California. On the high Sierras of Eastern-Central California, forests grow to 10,000 or 12,000 feet, while the ranges of Southern California do not reach the upper limits of forests. Few of the ranges of Nevada reach the timber-line, which varies from the height of 9,000 feet in the northern to probably 11,000 feet in the southern part of the State. In Ari-

zona, probably none of the mountains reach the timber-line except the San Francisco group and the Sierra Blanca, where the line is at 11,000 and 12,000 feet. In New Mexico, the line averages about 12,000 feet above sea-level, and the higher annual temperature of the southern part of the Territory is fully compensated for by the greater altitude of the plateau in the northern part. In Colorado, the line rises from 11,000 feet in the northern to 12,000 feet in the southern part of the State; in Wyoming, from 10,000 to 11,000 feet in the Wind River and Teton Ranges, to about 11,000 feet in the Park Range; in Montana and Idaho, it ranges at from 9,000 to 10,000 feet, and in the Uintah and Wahsatch Ranges of Utah it is at about 11,000 feet. It is evident, if these considerations hold good, that the upper limit of timber must have approximately the same mean annual temperature everywhere. This temperature can not be measured directly for different places, but may be estimated by calculation by taking the mean temperature at some base in the neighborhood, and allowing a degree of fall for every three hundred feet of additional elevation. A calculation made on this basis for thirteen mountains, including Mounts Washington and Marcy, and several Western peaks, gives a mean of 30.4°, the extremes being 28° and 33°.

The Soil and Scarlatina.—Dr. Eklund, of Stockholm, Sweden, has for several years devoted much time to the pathology and etiology of scarlatina, and has reached conclusions of high practical importance in the light they throw upon the connection between bad drainage and other insanitary conditions and outbreaks of that disease without actual infection. He has constantly found a prodigious number of discoid bodies in the urine of persons suffering from scarlatina, and most positively asserts that he has also noticed those identical organisms in vast numbers in the soil and ground-water of the Isle of Skeppsholm; in mud from the trenches, dug for the water-mains; and among the greenish molds of the walls of the old barracks, where scarlatina was most rife. He furthermore alleges cases of scarlatina occurring in children after drinking milk mixed with the ground-water of the island, and one case which followed an immersion in one of these trenches, and the drying of the child's clothes in a small room. In still another case scarlatina broke out in a block immediately on the exposure of the ground-water by excavations around. These observations, however, and those of other persons who have found micrococci in the animal fluids in scarlatina, even if the organisms are observed to be invariably present, can not be held to prove that they are the cause of the disease till the fact has been directly verified by inoculation into a healthy body carefully isolated from all other sources of infection.

Lip-Teaching for the Deaf and Dumb.—Earl Granville, as President of the Association for the Oral Instruction of the Deaf and Dumb, had occasion recently, at a meeting in behalf of the system, to remark upon the satisfactory progress that had been made in lip-teaching, by which the deaf were placed in a position to converse with their fellow-creatures without the aid of signs. The number of pupils in the association's school had increased, and favorable reports had been received from the class of the School Board of London. Except where idiocy or mental incapacity existed, this method of teaching was applicable to all cases. Its advantages had been acknowledged in a remarkable degree at a conference lately held, where a consensus of opinion was expressed in its favor. In evidence of the great benefits the system conferred upon persons trained under it, Earl Granville mentioned that several former pupils of the school were present who were now earning their living in positions which they would hardly have obtained had they been educated by the system of signs. An examination was afterward had of pupils of the training college and school, in which they showed that they understood, by watching a speaker's lips, what was said to them, and could make intelligible replies to it.

Chaldean Astronomy.—The invention of astronomy is ascribed to the Chaldeans by some ancient writers. It is said that a certain Zoroaster, King of Bactriana, was the first who observed the stars, about 1700 B. C.; although, according to Porphyry, Cal-

listhenes found at Babylon and sent to Aristotle a series of observations going back to the earlier date of 1903 B. C. As yet, however, the Chaldean observations with which we are acquainted are reduced to the account of three eclipses of the moon that took place about 719 B. C. Hopes were entertained, when the discoveries of cuneiform tablets were made in the ruins of Babylonia and Nineveh, that trustworthy information of the real condition of astronomical science among the Chaldeans might be gathered from them; but it was some time before anything of this kind was realized. Messrs. Oppert and Sayce, it is true, found a few astronomical documents in the library of a king of Assyria, but they contained more astrology than astronomy, and were, moreover, too badly preserved to be of much use. Quite recently the Assyriologue, Father Strassmeyer, of the Society of Jesus, has found a few documents relative to astronomy in the Spartoli collection of the British Museum; and these have been carefully examined by Father Epping. They indicate that the Chaldeans had considerable knowledge of astronomy. Besides calculating the time of the new moon, and taking account of the thirds in their observations, they followed the courses of the planets, were acquainted with the retrograde movement of Mars, and referred the positions of the planets to those of the stars. If other results similar to these are at all extensively obtained from the immense amount of study yet to be made of the tablets, astronomers may hope to acquire materials of extreme value for the verification of their tables and the study of the system of the world.

Pedigree Selection in Food-Plants.—Major Hallett, in commending before the Brighton Health Congress his "pedigree system" for the improvement of food-plants, takes notice of the immensely greater advantages in favor of systematic improvement afforded by plants over animals. A cow or ewe, he says, "produces at birth one (or two) only; a single grain of wheat has produced a plant the ears of which contained 8,000 grains, all capable of reproduction. Now, we can plant all of these, and of the resultant 8,000 plants reserve only the best one of all, to perpetuate the race, rejecting every other." The principle of Major Hallett's system consists in applying this rule, of reproducing only the best plants of each lot in successive years. "Can anything approaching such a choice as this," he says, "be afforded any breeder of cattle or sheep, no matter how extensive his herd or flock?" Cereals, improved by Hallett's system, have now been cultivated in more than forty different countries in Europe, Asia, Africa, America, and Australia, with complete success everywhere, so far as reports have been received. A parcel of pedigree wheat taken to Perth, Western Australia, in 1862, where the average crop was ten bushels to the acre, produced from twenty-nine to thirty-five bushels to the acre, with seventy-two as the largest number of heads on one stool, and one hundred and thirteen grains in the largest ear. In 1881 the same wheat, or its descendant, produced, in New Zealand, seventy-two bushels on one acre; with more than ninety ears, some of them containing as many as one hundred and thirty-two grains each, on single plants. The same return—seventy-two bushels to the acre—was reported of three acres in Essex, England, in 1876, with one hundred and five ears, containing more than 8,000 grains, on one plant. Reports corresponding with this have been received from Brussières, France; Linlithgow, Scotland; Russia, Hungary, Italy, Holland, Denmark, and Sweden. The Hallett wheat withstood the frosts of 1875 and 1876 in Belgium, when other varieties were killed. In India, Sir Seymour Fitzgerald, Governor of Bombay, in 1870, reported the crop from the pedigree wheat to be fifty per cent greater in quantity and fifty per cent more valuable in quality than that produced from the best other seed that could be bought in the market. The same success has been obtained with barley and oats cultivated after this system. A friend of Major Hallett's, in Italy, applied his system to the sugar-beet, with the result of obtaining, after seven years of improvement, three times as much sugar and wine from the same acreage of roots as he had been accustomed to get at first. Experimenting with the potato, Major Hallett has started each year, for fourteen years, with a single tuber, the best of the year, cultivating for freedom from dis-

ease and for productiveness. Dividing the first twelve years of the fourteen into periods of four years each, he obtained for the first period an average of sixteen tubers from each single best seed-tuber; for the second period, nineteen; and for the third period, twenty-seven, or nearly double the yield of the first period. This plan of selection is on trial, in India, for cotton, and the reports so far received show already a marked difference in its favor.

The Mound-Builders in Mexico.—Mr. F. F. Hilder, in a paper on "The Archæology of Missouri," summarizes the results of the efforts of Mr. S. B. Evans to follow the works of the mound-builders down the Mississippi Valley, and connect them with the ancient works in Mexico. Beginning in Minnesota, Mr. Evans has, by personal survey, found an unbroken chain of these works along the great river to the Gulf, with colonies on the principal tributaries traversing the States that border on that stream. "Mounds were found along the entire route, and on the shores of the Gulf. Crossing into Mexico, the chain, dropped in the sea at Galveston, was recovered near Vera Cruz. On the plain of Cholula is a mound that, if transferred to Cahokia, would fit the landscape, and appear in general keeping with the works. On the other hand, if the great mound of Cahokia were brought in presence of Popocatepetl, it would not be abashed, but would be a fit companion of the pyramid. The pyramids of the sun and moon at Teotlihuacan would be mounds in Virginia and Ohio; and the great mounds of Grave Creek and Selzertown might embellish the 'ancient city of the gods.' Excavations were made in Mexican mounds, as they were made in the United States, and substantially the results were the same."

Elephant-Service in Africa.—Mr. L. K. Rankin, of the Belgian Elephant Expedition in Africa, has made a statement of the probable value of the practical service that may be expected from elephants if their introduction as carriers is attempted in that continent. When the expedition reached Mpwapwa, a report was drawn up to be sent to the King of the Belgians, which stated that "the elephant expedition has now been proved a complete success." This assertion was justified by Carter, the head of the expedition, now deceased, on the three counts of—1. The immunity of the elephants against the tsetse-fly after twenty-three days of exposure to that insect; 2. Their maintenance during one month mostly upon the uncultivated food of the country, and therefore at little cost (only about twenty-five rupees, or fifteen dollars, for four); and, 3. Their ability to march over all kinds of ground, soft, stony, sandy, boggy; to conquer all eccentricities of topography—hill and dale, river and jungle—while laboring under double their due weight of baggage, some fifteen hundred instead of seven hundred pounds; and this in a style that no other beast of burden could hope to emulate. This brilliant forecast received a seeming bitter contradiction in less than a week, when the largest and most valuable elephant, returning from a day's expedition, in apparently good health, suddenly lay down and died. Mr. Rankin believes that the death, which was followed shortly afterward by that of another elephant, was caused by exhaustion brought on by imposing too heavy loads and too severe labors upon the animal, combined with too great a change from the strong food it had enjoyed in India to the wild grasses of Africa. The animals had been stall-fed in India, "on the fat of the land," while in Africa they were turned out to forage for themselves, and very little corn and rice was bought for them. Whereas, according to Sanderson, seven hundred pounds is the limit-weight an elephant should carry on flat ground for a prolonged time, these animals bore at first twelve hundred, then fifteen hundred, and at one time seventeen hundred pounds; while they daily climbed the most tremendous hills. These views are enforced by the fact that, while the elephants were fat and round at starting, they had lost so much flesh by the time they reached Mpwapwa, that their backbones stood up six or seven inches from their flanks! These facts resulted from faults in management, in insufficiency of preparations for the expedition, and mistaken views of economy, and should not be allowed to prevail against the competency of elephants, under good management, to endure reasonable service, on which hardly any doubt is thrown. Dearly bought

experience, Mr. Rankin suggests, would another time remove the risks that were incurred; and he has not the shadow of a doubt that there is yet a great future in Africa for the elephant, especially when the stage of capturing and taming the native species has been reached.

Co-operation of Medical Officers and People in Sanitary Objects.—The Sanitary Aid Association of St. Leonard's and Hastings, England, during nine years of work among a population of thirty-five thousand, has secured a co-operation between the people and the sanitary officers, under which the spread of all infectious diseases has been effectually prevented. This it has done by tact in the exercise of its functions as a medium between the medical officers and the people. It seeks, first, to guard against popular jealousy of inquisitorial inspection. The teachers of the schools are expected to make weekly returns of all absentees, with the cause of absence if known; if the cause is not known, some fit person is deputed to make a friendly casual visit to the family, without any suggestion of suspicion of fever, and report the information received to whoever acts as sanitary manager. The case is then put into the hands of the health officer, and his endeavors are furthered by explaining to the mother that she shall receive, for the strict performance of the processes of disinfection taught her, assistance, to be allotted according to the circumstances of the family. The assistance may come in the form of a milk allowance, beef-tea, wine, or whatever may be ordered by the medical attendant, a nurse, or a person to do the washing, or, where no want exists, of little delicacies and comforts which may be given without offense. It should always be connected with obedience, by the persons assisted, of the inspector's orders, and should be accompanied, through the period of illness, by the promise of suitable help at the end. The greatest difficulties the medical officers have to meet arise from the desire of the poor to conceal their cases, for fear of injuring their business; but, under the operation of this system, every family that enjoys the benefit of its application and finds out what help and relief it gives tells the neighbors, and so it is brought about that the medical officer becomes himself the poor man's accepted friend. The St. Leonard's and Hastings society has never incurred a failure during all the years of its working; yet so unobtrusive have been its operations that one who should go down to inquire at random about it, without having a list of its allies, would have difficulty in discovering its existence. By adhering to and avowing the principle that it has no more right to interfere with the persons it visits than they with its members, by using persuasion and sympathy instead of threats, it has reduced the number of unmanageable cases to one a year; and has always brought even these around by taking care in conversing with the persons to give full information respecting disinfection. Thereupon, they turn around and act upon the information they have gained, so as to show how well they can do without their visitors.

Number of Species of the Orang-Outang.—The number of species of the orang-outang has been placed variously at from one to four. The upholders of the one-species theory have doubted whether the characteristics that were regarded as indications of specific differences might not really have arisen from the examination of skulls of different ages. To contribute to a solution of this doubt, Mr. Frederick A. Lucas has examined the large collection of orangs of Professor Henry A. Ward, and compared the notes taken by Mr. William T. Hornaday, while collecting orangs, and has satisfied himself that the views of the advocates of one species are correct. He previously believed that there were two species. He adds to his notes on the subject the suggestion that "they point clearly to the fact that it is extremely dangerous to form a species from observations of one or two skulls," and that they render it very probable that many fossil species have been based on individual or sexual peculiarities.

The Law of Land Formation on our Globe.—Professor Richard Owen, of New Harmony, Indiana, has observed some coincidences in the arrangements of continental lines and in the location and direction of elevations and depressions of the surface of the earth, which have suggested to him

a law by which dry land shows itself above the ocean, which he believes to be of almost universal application to geographical and geological phenomena. The coincidences which he describes may be traced by any one on a globe or a large map. The law, as Professor Owen has stated it in a paper on the subject presented to the American Association last year, is, in general terms: "The land on our globe shows itself above the ocean-level in definite multiple proportions, by measurement; the unit is the angular difference between the axis of revolution and the axis of progression. For convenience, as that angle has been lessening for centuries, we might call it 24°. We then have:

Geographical and geological unit	$= 24° = \frac{1}{15}°$
Greatest width and length of continents	$= 3 \times 24° = 72° = 1\frac{1}{2}°$
Radius for continents	$= 36° = \frac{2}{10}°$
Half radius "	$= 18° = \frac{1}{30}°$

The measure for oceanic distances is the complement of 24° = 66°. The ratio of land to water, as shown by Professor Dana, is as 100 : 275. The ratio of 24° : 66° : : 100 : 275. All measurements are to be estimated at the equator.

Regarding his law in detail, Professor Owen finds, first, that many longitudinal elevations and depressions on the earth's surface (the result apparently of cooling and contraction), especially near the greatest median—north and south—extension of each continent, coincide with some meridian. This shrinkage has caused a north and south continent to appear in each of the four quarters of the earth, going around on the equator. Minor north and south extensions can be traced at intervals, often of 4½° or 9° apart all around the globe, alternating usually with trends which form with them angles of 23½°. In verification of this law, adjust the globe so that the poles shall be at the wooden horizon and the eastern extremity of Brazil at the brass meridian. Then we shall find the two Americas occupying one, Europe and Africa the second, Asia and Australia the third, and North and South Oceania the fourth, of the quarters into which the rules divide the globe. It will be found that great elevations are matched by depressions on the opposite side of the globe, as the Himalayas and Central Asiatic table-land with Hudson Bay, the American lakes, the Gulf of Mexico, and the deep southeastern Pacific at 180° from them. A second feature is that the outlines of continents form angles of about 23½° with meridians. If we examine the great continental outlines, we shall find in the circuit of the globe five eastern trends of great continents exactly 72°, or one fifth of 360°, apart. These trends mark belts of seismic force, or lines apparently where the crust has less thickness than under the median lines of continents. The rule of trends may be verified by lifting the north pole of the globe 23½° above the wooden horizon and bringing the continental trends under the brass meridian. Professor Owen finds, third, that besides these two forces which exert their powers along lines parallel, respectively, to the axis of revolution and to that of progression, each continent has two foci nearly on its median line, concentric circles around which mark important additions to the land and orography of the continent, and pass, as they successively enlarge, through areas of consecutive geological periods from the older to the newer. One of the foci, and the dominant one in the northern continents, is near the Arctic Circle; the other is in the geographical center of the continent. The southern continents have only the latter. The foci for North America are in Boothia Felix, near longitude 96° west, and latitude 71° north, and near the height west of Lake Superior, longitude 94° west, and latitude 48° north. A radius of 24° from the northern focus reaches the southern limits of the archæan area near Lake Superior and its junction with the palæozoic; and one of 29° or 30° takes in the mesozoic of Kansas and the new red sandstone of Connecticut and Massachusetts, with a valley of erosion between. Drawing our circles from the west shore of Lake Superior, a radius of 11° or 12° gives us Silurian, lower and upper, from Niagara to near Springfield, Ohio, Lexington and Frankfort, Kentucky, and Nashville, Tennessee, dominating at least the eastern half of the circle, while the western part was still under water. A radius of 12° to 13° marks the Appalachian and other coal-fields; and of 15°, the mesozoic formation curving from the cretaceous of Utah and Colorado through the interme-

diate of Arkansas and Tennessee to that of New Jersey. A radius of from 18° to 24° takes in the marine tertiaries of the East and the West; one of 24° marks the main outlines of the continent; while one of 36° takes in the extreme points of the continent in all directions. The rule is applied with almost literal similarity to the other continents. Professor Owen furthermore maintains that the western Alps became a dynamic focus at about the beginning of the Cenozoic period, and that Monte Rosa is nearly the center of the dry land of the globe, whence a great circle of immense seismic activity may be traced nearly parallel with the Asiatic continental trend to the Himalayas and thence around to the Andes and the South American earthquake-region. Another great circle is nearly parallel to the North American trend, and includes the volcanoes of Central America and the geysers of Iceland, and incloses and probably aids to heat our Gulf Stream.

Value of Disinfectants.—Dr. George M. Sternberg, surgeon in the United States Army, has reported upon the results of experiments he has made with various disinfectants and vaccine virus, the conclusion drawn from which is that chlorine, nitrous acid (nitrogen dioxide), and sulphurous acid (sulphur dioxide), are reliable disinfectants in the proportion of one volume to one hundred volumes of air. Probably a considerably smaller proportion of these disinfectants would be efficient in destroying the potency of thin layers of virus in a moist state, or of virus exposed to the action of the disinfectant in an atmosphere saturated with moisture. Experiments with carbolic acid, on the other hand, "show that the popular idea, shared perhaps by some physicians, that an odor of carbolic acid in the sick-room or foul privy is evidence that the place is disinfected, is entirely fallacious, and, in fact, that the use of this agent as a volatile agent is impracticable, because of the expense of the pure acid and the enormous quantity required to produce the desired result."

A Selenium Photometer.—M. Léon Vidal has devised a photometric apparatus of selenium, for measuring the intensity of natural or artificial light by means of an action purely physical and mechanical, and in a manner analogous to that by which we measure the temperature and the amount of atmospheric pressure with the thermometer and the barometer. The difference in conductibility which results from the action of light on selenium produces deviations in the needle of the galvanometer which correspond in extent with the intensity of the luminous source. In this manner we may determine, at a glance, the intensity of light at any instant. The principle is applied to the construction of meteorological photometers, for which elements of selenium of equivalent conductibility are provided, to be substituted for each other as their molecular condition becomes modified; the plates may be restored to their normal condition by heating them, and used again. This instrument may be employed for the rapid and visible record of the instantaneous changes in luminous intensity, at all heights and depths, the observer reading the indications of the galvanometer at the place which may be most convenient for him.

NOTES.

THE American Public Health Association will hold its tenth annual session at Indianapolis, Indiana, October 17th to 25th. Papers will be presented on the different action of disease in the white and black races, the removal of excreta, heredity, sanitary associations, vaccination, intermittent fever in New England, sanitary organization, cattle-disease, etc., etc., with reports of committees on the prevention of venereal disease, compulsory vaccination, the management of epidemics, statistics, cattle-diseases, National Museum of Hygiene, incorporation of the Association, and necrology.

THE American School of Classical Studies at Athens, Greece, under the direction of a committee of the Archæological Institute of America, is to be opened on the 2d of October. Its object is to promote the study of classical literature, art, and antiquities, by graduates of American colleges, and to prosecute and aid original and co-operative research in those subjects. The school is open, free of fees, to bachelors of arts, properly recommended from co-operating colleges. Nine colleges in New England, New York, New Jersey, and Baltimore, have contributed annual subscriptions of $2,250, most of them for ten years, in aid of the school.

Dr. H. P. Stearns, of the Hartford (Connecticut) Retreat for the Insane, accounts for the increased amount of disease of the nervous system observed of late years, by reference to the larger part of the twenty-four hours which the masses of the people spend within-doors. A far greater part of the population than used to be are employed in counting-houses, business-offices, stores, and factories, inhaling a heated and contaminated atmosphere, the effect of which upon the delicate structure of the brain can not but be most unfavorable.

Mr. H. W. S. Cleveland, in his important pamphlet on "The Culture and Management of our Native Forests," says that we must learn to imitate Nature in our methods of cultivation, if we would grow new forests successfully. The primary point is to keep the trunks of the trees shaded. Nature does this by massing the plants closely together in the forests, so that they shade each other, or by giving a wide spread of limbs with low heads to trees in the open. It also protects the cambium layer with thick deposits of old bark, and we endanger the health of the tree when we scrape this off. Another important point is to keep the roots well mulched, as nature does with old leaves, thick mold, and mosses in the forest; and a third point is to protect the trees well from the southwest wind—the breeze which, with its drying heat, is the most damaging to the vitality of the tree. In illustration of the validity of this rule Mr. Cleveland points to the greater luxuriance and variety of plant-life on the east side of seas and lakes than on the west side.

Professor Francis Maitland Balfour, of the University of Cambridge, lost his life about the 19th of July, while attempting the passage of the Aiguille Blanche de Penteret, one of the buttresses of Mont Blanc, in Switzerland. He was only about thirty years old, but had done a very large amount of original biological work for one so young. Having entered Trinity College, Cambridge, as a natural science scholar, he decided, upon the suggestion of Professor Michael Foster, to apply himself at once to original work instead of going through the ordinary routine preparation for his degree. He was afterwards engaged at the zoölogical station at Naples, and then at Naples and Cambridge alternately, and had just been honored by the creation of a special chair of Animal Morphology for him at the university. He was the author of a work of eminent merit on the "Development of the Elasmobranch Fishes," and had begun a work on "Comparative Embryology."

The English unit, or parliamentary standard, for the estimation of the intensity of light, is a spermaceti-candle, six to the pound, burning 120 grains an hour. The French standard, or carcel, a lamp burning 42 grammes of refined colza-oil per hour, with a flame 40 millimetres high, is reckoned as equivalent to 9·5 candles. The English standard for gas-lights is an Argand burner with sixteen holes, in a chimney five inches high and two inches in diameter, burning five feet of standard gas per hour, and giving a light of sixteen candles. The German standard, or *Vereinskerze*, is a paraffine-candle 20 millimetres in diameter, with a flame five centimetres high, 7·6 of which are equivalent to a carcel. The variations of the carcel burner do not exceed two or three per cent, while those of the standard candles sometimes rise to thirty per cent.

The later experiments of Professor W. O. Atwater and his aids on the effects of fertilizers and the feeding capacities of plants, as recorded in a paper just published by the Agricultural Department, indicate that Indian corn has a much greater power of gathering nitrogen from the soil or air or both than it has been credited with; that in this respect it comes nearer to the legumes than to the cereals; and that it may eventually claim a right to be classed with the "renovating" crops. The experiments are, however, not yet considered decisive. Professor Atwater, projecting a plan for continued experiments in the line to which his report is devoted, suggests that chemical and physical surveys of the land in behalf of agriculture ought to be undertaken, just as there have been topographical and geological surveys in behalf of other industries and interests.

The death is announced, July 16th, of Dr. George Dickie, Professor of Botany in the University of Aberdeen, Scotland, for seventeen years, and previously for several years in the Queen's College, Belfast. He retired from active duty, on account of impaired health, in 1877. He was the author of numerous papers and several books on botanical subjects. He was especially interested in the study of algæ.

Professor William Stanley Jevons, the philosopher and Professor of Political Economy, was drowned while bathing at Bexhill, near Hastings, England, August 15th. Professor Jevons was a grandson of William Roscoe, the merchant author, and was born in Liverpool, in 1835. He was connected with the Royal Mint at Sydney, Australia, for five years after 1854, and was appointed Professor of Logic and Moral Philosophy and Lecturer on Political Economy in Owens College, Manchester, in 1866, and Professor of Political Economy in the University of London in 1872. He was the author of several works in logic and political economy, which are recognized as authoritative.

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